PB 1840-B

Hydrangea Production:
Species-Specific Production Guide

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This is one of two Extension publications that discusses hydrangea production. This publication presents research-based production recommendations tailored to the primary species grown in the Southeast. Specific practices related to propagation, fertilization, blueing, irrigation, pruning and plant growth regulators are discussed. In the companion publication, "PB 1840-A Hydrangea Production: Cultivar Selection and General Practices to Consider When Propagating and Growing Hydrangea," general plant characteristics, species evaluations, and general production practices are covered. Detailed information is also provided on propagation and diagnosing nutrient deficiencies in the companion publication.

Figure 1. Small, infertile flowers (center) are inconspicuous yet help support pollinators. Larger, infertile florets (outlying) are showy but lack pollen or nectar for pollinators.

INTRODUCTION

The genus *Hydrangea* is expansive and includes approximately 1,000 species, hybrids and cultivars, which can be deciduous or evergreen shrubs, small trees or climbers. Hydrangea is the second most popular deciduous shrub in the U.S. and is produced in more than 1,500 nurseries nationwide. With more than 10 million plants being sold annually, accounting for 13.5 percent ($91,265,000) of annual U.S. shrub sales, hydrangea is a significant crop and offers tremendous opportunities for nursery producers. Four species are most commonly produced in nursery cultivation in Southeast and Mid-Atlantic nurseries. The taxa currently found in the trade in the U.S. include *H. arborescens*, *H. macrophylla* (including var. *normalis* and subsp. *serrata,* which is synonymous with *H. serrata* in the industry), *H. paniculata*, and *H. quercifolia*.

Hydrangeas commonly produced commercially are deciduous shrubs, selected for their showy inflorescence (flower), with some native to the U.S., others to Asia. The floral display of hydrangea is largely due to sterile florets, grouped into large rounded corymbs or conical panicles, and ranges from white to shades of pink, purple and blue. Fertile flowers are generally inconspicuous (Figure 1) *Hydrangea macrophylla* and *H. arborescens* have flowers in corymbs. For *H. macrophylla* and *H. serrata,* the flower form can be a traditional round corymb, commonly referred to as a mophead form, or lacecap form flowers. Lacecap flowers have flat to rounded flower heads encircled by showy sterile florets. Both *H. paniculata* and *H. quercifolia* have flowers in conical panicles. These panicles open from the base to the tip and continue to expand in length as they open. Flowers on some selections are prized for their ability to continue to develop color as they mature, creating an "antiqued" look (for example, *H. macrophylla* 'Blushing Bride' and *H. paniculata* Little Lime). Production of several species and cultivars of hydrangea as well as remontant blooming (rebloom during the season) selections of *H. macrophylla* can extend sales throughout the year.

SPECIES-SPECIFIC RECOMMENDATIONS

H. arborescens — Smooth Hydrangea

Smooth hydrangea is native to deciduous woodlands of New York, south to the Gulf states, and west to Iowa (USDA plant hardiness zones 3 to 9). With ample moisture, smooth hydrangea will grow well in full sun, especially in more northern parts of the U.S., but does best in partial shade in the Southeast. It is more tolerant of alkaline conditions than *H. macrophylla* and prefers moderate moisture levels. It flowers reliably from Florida to Canada. Leaves (immature and mature) are more frost-tolerant than those of *H. macrophylla* and *H. serrata*. Fall color is often brown but some years a clear yellow. Smooth hydrangea

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bears large, white corymbs at the shoot terminals starting in mid- to late May and lasting for six to eight weeks (Figure 2). Inflorescences of native populations consist primarily of small fertile flowers with a few large sterile flowers and thus may not be ideal for breeding stock.

Figure 2. Large, white corymbs crown the foliage of *H. arborescens*.

Propagation. *Hydrangea arborescens* is easy to propagate by softwood cuttings using 1,000 ppm indole 3-butyric acid (IBA), either in solution or talc. Stem cuttings often have 100 percent rooting within two to three weeks. Although *H. arborescens* roots readily through the summer and into September, it is recommended to collect cuttings early in the season and root them early enough in the season to promote growth and establishment as a liner to increase overwintering survival. For this reason, nurseries in USDA plant hardiness zone 6 or lower might collect softwood stem cuttings during the summer in order to reduce heating costs associated with fall weather and to provide enough time for stem cuttings to root prior to overwintering.

Production. Rooted cuttings are typically potted into #1 or #3 containers, depending on the size of cutting and crop cycle. Containers should be well-spaced to support branch development and lateral growth; #3 containers are often placed on 2-foot spacing. Plants in a #3 container can be bumped to a #5 container, which is the largest size of hydrangea typically marketed. Plants can be grown without shade, particularly in more northern environments. Stems are often not branched and can be stiff but weak and thus insufficient to support the large, heavy corymbs characteristic of cultivated varieties, necessitating other management practices such as pruning, plant growth regulators (PGRs), or irrigation management to control growth and avoid labor-intensive staking (Figure 3).

Figure 3. Due to weak branches and heavy inflorescence, *H. arborescens* may require staking or other management practices.

Nutrient management. Anecdotal landscape and container production information suggests *H. arborescens* can be grown using much less nitrogen than other hydrangea species. While *H. arborescens* White Dome required the high rate of five to six month 15-9-12 controlled release fertilizer to maximize growth when produced in Europe, no difference in growth of *H. arborescens* 'Annabelle' was observed in Michigan when produced with 26 g per #3 container (a very low rate) using a 19–5–9 CRF, and substrate pore water electrical conductivity was maintained between 0.5 and 1.0 dS/m (regardless if under normal or deficit irrigation). Correctly matching liners to container sizes can result in a finished plant within one season (approximately four months).

Irrigation. In Michigan, there were no growth differences for *H. arborescens* White Dome regardless of whether partial or full daily water replacement was employed. However, water use was substantially reduced with partial replacement irrigation schedules. In a Michigan study, *H. arborescens* Incrediball used approximately half the water when compared to *H. paniculata* 'Limelight.'

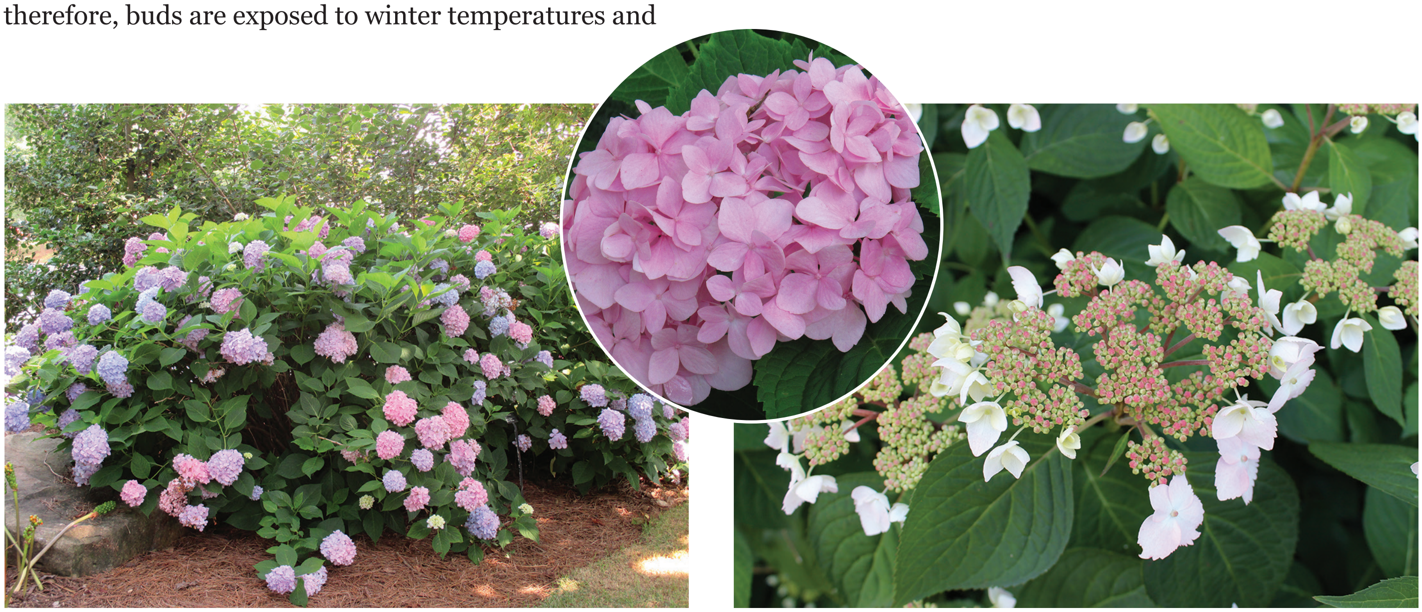
Partial daily water replacement — Irrigating with a volume of water that partially replaces the amount of water used by the plant and lost to evaporation since the previous day's irrigation event.

Full daily water replacement — Irrigating with a volume of water that replaces the entire amount of water used by the plant and lost to evaporation since the previous day's irrigation event.

Pruning. *Hydrangea arborescens* will need to be pruned multiple times each season during production to produce full, densely branched plants that ultimately produce many blooms, which form on new growth. Avoid pruning in the spring, the season of sale, as that can delay flowering. Note the problems mentioned above associated with weak stems and large, heavy corymbs.

H. macrophylla — Bigleaf Hydrangea

Bigleaf hydrangea is native to Japan and Korea. Plants usually grow 3 to 6 feet high, but can grow to 10 feet with width becoming equal to or greater than plant height. Bigleaf hydrangea is considered hardy in USDA plant hardiness zones 6 to 9. However, hardiness varies among cutivars, and selection must be made carefully to match the location. Cold injury to the flower buds and improper pruning are the usual reasons for flower failure in the landscape. Bigleaf hydrangeas form flower buds during late summer and fall; therefore, buds are exposed to winter temperatures and can be damaged by low temperatures. Flower color ranges from pink to lavender to blue depending on cultivar and soil chemical properties (Figure 4a). There are also a few white-flowered cultivars whose flowers may turn very pale pink or blue as they age. Two horticultural groups of *H. macrophylla* are recognized — mopheads, also called hortensias, and the lacecaps. Mopheads have large, round corymbs consisting primarily of large, sterile flowers (Figure 4b). Lacecaps have an inflorescence consisting of an outer ring of large, sterile flowers and an inner core of small fertile flowers (Figure 4c). Some selections, both mophead and lacecap, are remontant and will rebloom later in the season. Bailey Nurseries' remontant selection, The Original Endless Summer (Hydrangea 'Bailmer'), and marketing efforts related to it are credited, at least partially, with the resurgence in hydrangea popularity.



Figures 4a, b, and c. (a) Even on a given plant, shown here The Original Endless Summer *(Hydrangea 'Bailmer')*, the flower color can vary; (b) a mophead, or hortensia, flower type; (c) a lacecap flower type.

Propagation. *Hydrangea macrophylla* is easy to propagate by softwood, semi-hardwood or hardwood cuttings, although softwood cuttings are most common in the trade (Figure 5). A 1 peat:1 perlite substrate with intermittent mist is recommended for softwood cuttings. Terminal softwood cuttings treated with 1,000 ppm IBA, either in solution or talc, rooted in three to five weeks at near 100 percent, yet success near 100 percent is also reported for untreated softwood cuttings. *Hydrangea macrophylla* can also be propagated by semi-hardwood cuttings using a 5-second basal dip in 500-1,500 ppm of the potassium (K) salt of IBA (K-IBA) or by hardwood cuttings set directly outdoors in pine bark substrate, but these are less commonly used methods. Hardwood cuttings rooted at approximately 50 percent, with some remontant cultivars rooting at 80 percent by late spring the following year. Rooting leaf bud cuttings and single bud cuttings successfully has also been reported. For alternatives to K-IBA, see Boyer et al. in the References and Additional Resources section.

Figure 5. Softwood cuttings of *H. macrophylla*.

Production. Typically, liners rooted in trays or 2-inch containers are transplanted into a #1 or #3 container filled with pine bark-based substrate. Quart liners of *H*. 'Nikko Blue' and similar cultivars transplanted in the spring into #5 containers can finish by fall. In a study that included pine bark, peat and less traditional container substrate components, the optimum container substrate was 3 peat:1 bark. Additionally, plant biomass increased as container size increased from 0.24 gallon to 1.2 gallons. Bigleaf hydrangea is normally grown under shade in the southeastern U.S.

High summer temperatures greater than 86 F during the day are known to interfere with normal flower and vegetative development. Additionally, high night temperatures, 80 F or higher, are potentially damaging to previously formed floral primordia, delaying, distorting or preventing new flower development and/or causing vegetative distortion. The severe southeastern U.S. heat wave of June 2015 appears to have been sufficient to prevent many *H. macrophylla* selections from blooming while in production and prevented sales at least for some producers. Root restriction in container production can also reduce flower initiation.

Yellow foliage, chlorosis and weak root systems can be problems during nursery production of *H. macrophylla*, particularly in midsummer. This problem has been attributed to overwatering, root rot and low iron uptake. A composted bark, mini nugget substrate with desirable physical properties (air space 39 percent, container capacity 53 percent, available water 21 percent, unavailable water 32 percent, bulk density 0.2 $g{\cdot}cm^3$, and cation exchange 8.1) produced the best growth of five different substrates tested for #1 and #3 plants. The 9:1 bark to kaolin clay substrate resulted in the least amount of growth.

Liners should be a minimum of 6 inches tall (bare root), or 1 quart or larger (container), when lined out for field production. Bigleaf hydrangea requires a site that has good drainage yet can withstand poorer soils than many other woody nursery crops. *Hydrangea macrophylla* benefits from supplemental water during dry periods. When temperatures are above 85 F, plants in full sun can wilt, even when provided with adequate moisture.

Nutrient management. In Ontario, Canada, 1.3 to 2.3 pounds per yd^3 was the optimal rate of 19-6-13 plus minors, eight to nine month controlled release fertilizer (CRF) for #2 bigleaf hydrangea. In a study with a variety of mulches (geotextile discs, coco discs, plastic discs, hazelnut shells, sawdust, Biotop and crumb rubber) applied to container-grown plants, hydrangea growth, quality and foliar color were better when fertilizer was placed under the mulch.

Low phosphorus levels have the potential to prevent excessive algae growth in reclaimed water and have the added benefit of conserving a natural resource. Phosphorus levels of just 0.29 pounds/yd^3 P_2O_5 were sufficient to produce desired growth and quality. Rates as high as 0.53 pounds per yd^3 P_2O_5 are commonly used and appear to be excessive. See Flower Color Management section for further details.

Irrigation. *H. macrophylla* is considered a heavy water user and wilts easily under water deficit; however, differences among cultivars exist. Average daily water use of 'Fasan'' (7.8 fl. oz. per day) varied from that of 'Pia' (7.0 fl. oz. per day) when grown in #2 containers outdoor under 40 percent shade. However, both species used approximately 4.5-5.0 gallons of water over a two and a half month period. However, opportunities exist to refine irrigation applications, as the reputation of a heavy water user seems to promote overirrigation of this species. 'Mini Penny' irrigated at 20 percent volumetric water content (considered "dry" by many growers) used less water by half than the nursery standard irrigation regime yet had no reduction in growth. Nutrient leaching was also reduced by reducing irrigation volume. Water uptake does seem to be restricted to higher volumetric water content (VWC), at least for some selections, which may partially explain the reputation of hydrangea as a heavy water user. Water uptake by 'Fasan' decreased at 28 percent VWC and ceased at 16 percent VWC. Daily light integral (the amount of light that a crop receives over the course of a day) is an accurate predictor of 'Pia' and 'Fasan' daily water use; plants grown under heavy shade require less irrigation compared to plants grown with greater light exposure.

Moisture content in both the container substrate and plant can be regulated through irrigation management, in turn controlling growth and in some cases reducing or eliminating the need for PGRs. For 'Hermann Dienemann,' 'Nymphe,' and 'Renate Steiniger,' cool morning temperatures, reduced irrigation (2.8 fl. oz. per 6-inch pot per day), and the PGR daminocide all reduced shoot length similarly in plants being forced in controlled environments. Increasing the irrigation volume (irrigating with 4.4 fl. oz. or approximately 3.7 fl. oz. per 6-inch pot per day) earlier in production increased height, plant width and leaf area. Conversely, increasing irrigation at the end of the production cycle did not lead to greater shoot growth but did improve inflorescence development. 'Leuchtfeuer,' produced in 2 white peat: 3 composted bark (0.40-0.80 inch) and subjected to a water-limiting irrigation regime, had reduced leaf area, height and flower size, but quality and compactness were increased. In a study with a variety of mulches (geotextile discs, coco discs, plastic discs, hazelnut shells, sawdust, Biotop and crumb rubber) applied to container-grown plants, there was no appreciable difference in water use of mulched and nonmulched 'Fasan' and 'Endless Summer,' suggesting that plant transpiration, and not substrate evaporation, is the greater component of daily water use.

General flower color management. Bigleaf hydrangea is popular in part because some cultivars have blue flowers (sepals), yet flower color can be manipulated to produce a range of colors from pink to lavender to blue (Figure 6). The color intensity is determined by a cultivar's inherent ability to produce blue pigment, aluminum availability in the soil or substrate as managed by aluminum addition and pH, and a cultivar's ability to uptake aluminum. When the soil/substrate pH is acidic (4.5–5.5), sepal color can be expected to be blue because aluminum is generally highly available at a low pH. At pH ≥ 6.0, sepal color is most likely pink. Between pH 5.5 and 6.0, sepal color might be pink, blue or lavender, or a mixture of pink and blue flowers may be present on the same plant. This is highly dependent upon cultivar. The flower color is not permanent. There are a few cultivars, such as 'Pia,' 'Masja,' 'Alpengluhen,' and 'Todi,' that do not turn blue regardless of soil pH, or they have several colors on an individual inflorescence. At low pH, these flowers may turn an unattractive muddy-red. Additionally, some new selections such as *H. macrophylla* BloomStruck are hybrids that do not turn blue readily regardless of cultural or production practices, resulting in florets with blue-purple (blurple) coloring.

Figure 6. Multitude of *H. macrophylla* colors (blue [left], "blurple" and multitude colors of pink [right]) as a result of pH and subsequent aluminum availability.

Container flower color management. Nursery growers report that they sell on average 10 blue hydrangeas for every pink one, so controlling the color is crucial. To produce a blue-flowered bigleaf hydrangea in containers, the substrate, water and mineral nutrition of the crop must be managed closely to ensure aluminum remains available (Figure 7). Substrate pH should be maintained at 4.5 to 5.5; however, some growers will target a pH of 5.0 with a resulting pH of 4.5 or greater and produce a successful crop. However, other mineral nutrient deficiencies (calcium, magnesium or aluminum) or metal toxicities can occur because bigleaf hydrangea cultivars tolerate or prefer alkaline conditions, yet they are grown in acidic substrates; therefore, incorporate ground or coarse dolomite as needed to amend the substrate at a rate to maintain desired pH and ensure adequate amounts of calcium and magnesium for plant uptake. Variables that affect aluminum availability include substrate components, substrate amendments including lime and phosphorus, how long ago the plants were potted, the quality of irrigation water, the amount of rainfall and irrigation to which the plants have been exposed, and the formulation, application method and rate of fertilizer. Testing the water supply is crucial to gain the necessary information on water pH and alkalinity.

Figure 7. To ensure the highly desirable blue sepals on *H. macrophylla*, water, substrate and nutrients must be closely managed.

The aluminum in aluminum sulfate lowers the pH, making the aluminum available for uptake by the plant. Incorporation of aluminum sulfate at a rate of approximately 12.5 lbs per cubic yard of substrate is likely required as soilless substrates have little or no aluminum. If the substrate pH >5.5 or aluminum was absent during potting, topdress with a polymer-coated aluminum sulfate at the labeled rate or drench a moist container at a rate of approximately 1.5 oz. (45 g) per gal. (10 lbs aluminum sulfate per 100 gal. of water) before the flower buds form in order to increase blueness of the flower color. However, caution should be exercised, particularly when plants are experiencing a midday wilt or no lime is included in the substrate, as injury and plant death have occurred from applying labeled rates, including rates below the maximum rate. Apply the rate you have selected to a few plants and observe them for approximately five days before applying to the entire crop.

Ideally, aluminum should be available from potting to sale. Drenches should be repeated every 10 to 14 days and should *not* coincide with fertigating with a complete fertilizer containing phosphorus. Phosphorus can bind to aluminum, making it less available. Guides for greenhouse production of florist hydrangea recommend fertigating with moderate nitrogen, no or low phosphorus, and high potassium; therefore, using an incomplete fertilizer with a ratio of 6N: 1 P_2O_5: ≥6K_2O is preferred when forcing hydrangeas and/or targeting blue flowers. Additionally, if acidifying irrigation water, use sulfuric acid or nitric acid instead of phosphoric acid to minimize the interaction of phosphorus and aluminum to maximize aluminum availability. Aluminum toxicity can damage or kill roots, stunt plants, and cause leaves to drop and the smaller flowers to abort. Plant death can also occur; therefore, use of aluminum sulfate must be done carefully and on a small scale until the grower becomes familiar with how the plants will respond in their individual production system. Not only can too much aluminum damage crops, but so can a pH that is too low.

Specific heated/fired clays or industrial mineral aggregates may also provide a mechanism for delivering aluminum to the crop with less risk of subjecting plants to an extremely low pH or aluminum toxicity. Including 10 percent Kaolite (v/v), a calcined clay mineral, in the potting substrate increased aluminum and sepal blueness. Plants grown in 10-20 percent zeolite (mined from volcanic rocks and ash layers reacted with alkaline groundwater) precharged with aluminum produced blue sepals when it was the only source of aluminum. However, growth was reduced at 30-40 percent zeolite. Adding calcined clay and aluminum sulfate supported blue sepals even at higher pH values. Increasing levels of Pozzolan (thermally activated kaolin-clays), and/or aluminum increased blue color and consumer desirability ratings, both of which were best when aluminum sulfate and Pozzolan were used in combination (Figure 8).

Figure 8. *H. macrophylla* produced without (bottom) and with (top) a Pozzolan clay-amended Douglas-fir bark substrate with no additional aluminum added.

To produce pink hydrangeas, avoid supplying aluminum to plants and maintain a substrate pH >6.0 by amending substrate with lime or dolomite (Figure 9). Use phosphoric acid to adjust irrigation water pH as needed. Use a conventional controlled-release fertilizer or liquid feed with a rotation of calcium nitrate and ammonium phosphate, normal phosphorus levels, and low to moderate levels of potassium. Overcome iron deficiency with iron sulfate or chelate and ammonium nitrate fertilization. Iron deficiency will be most prevalent when pH is > 6.4.

Figure 9. Pink *H. macrophylla* require a substrate pH closer to 6.0 and may be more prone to iron deficiency than when grown to produce a blue-flowered crop.

Field production flower color management. As opposed to soilless substrates used in container production, mineral soils normally have sufficient levels of aluminum. Therefore, elemental sulfur rather than aluminum sulfate is recommended. The sulfur is necessary to lower the pH to 4.5-5.5, so that the naturally occurring aluminum is available to plants. Because aluminum can become toxic at low pH, additional aluminum as would be supplied by aluminum sulfate is not desirable. Before planting any crop or adjusting pH, a soil test is necessary. Field-grown bigleaf hydrangeas can be induced to bloom blue by lowering the soil pH several months in advance of bud set (six months if pH is high). However, lowering the pH rapidly with a large amount of sulfur can cause the soil pH to go below 4.0, which can damage or kill roots.

Pruning. *Hydrangea macrophylla* growth can become rank and require multiple prunings per season. It has been trained as a standard form (Figure 10). This species generally flowers on old wood, so it should not be pruned after bud set starting in late summer through bloom the following season or the buds will be pruned away. If drastic pruning is needed, such as to reduce size, do it right after flowering. Remontant bloomers, those that bloom throughout the season on new growth, have more flexibility regarding pruning. In a study that examined pruning at 2 to 3 inches above substrate level (rejuvenation pruning), pruning halfway back (to the previous years' growth), or no pruning, #3 bigleaf hydrangea had about 30 percent more blooms when pruned halfway back than when the plants weren't pruned. Bloom number for rejuvenation pruning was not different from unpruned controls.

Figure 10. *H. macrophylla* can be produced as a standard form.

Figure 11. Terminal softwood, semi-hardwood (shown) and hardwood cuttings all root readily when treated with a rooting hormone.

H. paniculata — Hardy Hydrangea

Hardy hydrangea is native to Japan and eastern and southern China. It is cold hardy to USDA plant hardiness zone 4, making it one of the most cold hardy hydrangea species. Hardy hydrangea can grow to 10 to 20 feet in height and spread and can be trained as a small tree. Some selections have a very rigid habit with a coarse texture. Hardy hydrangea is generally very easy to grow. Most newer cultivars were developed to not grow as large as the species and have a more refined texture. Beginning with the introduction of the cultivar 'Tardiva' and then 'Limelight' in 2002, hardy hydrangea's popularity resurged.

Hardy hydrangea can grow under full sun to light shade, is pH adaptable, but requires good drainage. It can tolerate urban environments and drier soil conditions (once established) better than most other hydrangeas in the trade but also can wilt during drought and high temperatures. Hardy hydrangea generally flowers in midsummer, beginning in mid- to late June and lasting until October, depending on the cultivar and location. The inflorescences are large panicles, 6 to 18 inches long, that contain both fertile and sterile flowers. The flowers can cause the branches to bow over in a graceful arch when in container production. Flowers open white and often age to a pale to medium pink. However, the change to pink is more consistent in cooler climates, and cultivars that can age to pinkish purple colors may not do so in warmer areas.

Propagation. Terminal softwood cuttings of *H. paniculata* will root in a well-drained substrate, such as sand and peat, in approximately four weeks with 1,000 ppm IBA quick dip or talc. Untreated cuttings do not root in high percentages. This species can be rooted as late as September. Semi-hardwood and hardwood cuttings also root. Hardwood cuttings require a rooting hormone (Figure 11).

Production. *Hydrangea paniculata* is a vigorous species even in container production. Medium labeled rates of fertilizer are sufficient. A 2 ¼-inch liner will finish a #3 container in four to five months. Minimal care is needed while in production. Pruning twice a season and/or PGRs are typically used in an effort to increase branch number, flowers and plant density. In a nonscientific study, consumers preferred more but smaller flowers when compared to plants with fewer but much larger inflorescences. It can be produced in full sun, but partial shade is used further south.

Irrigation. *Hydrangea paniculata* is considered more tolerant of dry conditions than *H. macrophylla* but is a high water user and will take advantage of abundant water, unlike *H. quercifolia*. Under 100 percent daily water replacement regimes, *H. paniculata* 'Limelight' used more water than any other irrigation treatment species combination, approximately 0.7 inch per #3 container per day, which was twice as much as *H. arborescens*. Irrigation regimes that supplied less than the daily water use led to smaller plants for 'Limelight,' whereas other shrub species in the study were not smaller. However, *H. paniculata* 'Unique' had higher water use efficiencies under irrigation regimes supplying partial daily water use and had no difference in growth compared to replacing 100 percent of water lost, suggesting irrigation volume could be further reduced without a growth reduction. Additionally, 'Unique' may be a viable selection where *H. paniculata* is desired but persistent water shortages exist. Researchers at Michigan State University developed seasonal crop coefficients for *H. paniculata* 'Limelight' (6.07 in 2009 and 5.46 in 2010).

Hydrangea paniculata 'Grandiflora' irrigated with water containing 2.4 ppm free chlorine had no damage until approximately day 60 of using this water source, when 5 percent of flowers and matured leaves exhibited some symptoms but were not rendered unmarketable. At approximately 75 days, new and more severe damage was present.

Pruning. *Hydrangea paniculata* flowers on new wood so it can be pruned in winter or early spring. Plants can be pruned immediately following blooming and may bloom again. For field production cut back to within 6 inches of ground in February to March after the first growing season and after the second growing season if not sold. Pruning plants in container production can lead to different flowering results than for those planted in the field. Pruning can increase flower size in the field, although in replicated studies, hand pruned 'Limelight' and Little Lime in #3 containers had fewer and smaller flowers than plants treated with water or PGRs.

Training a standard. *Hydrangea paniculata* can also be trained to a tree form and is the most common hydrangea in the trade to be trained as a standard (Figure 12). Typically, large cultivars are selected for standard forms. This training should begin at an early age in the nursery and will require a stake. To develop the tree form, select and stake a single strong stem and remove all other competing growth. Once the stem reaches the desired height, cut it back using a heading back cut to stimulate branching. Prune out the tips of new growth repetitively to develop a dense, bushy canopy. This can be done by cutting all top growth back to the same height or pruning the topmost branches back to slightly different heights, allowing the branches to emerge from a short section of the trunk rather than one point. While more time-consuming, a stronger standard can be produced by the latter technique. Allowing small branches to remain on the trunk temporarily will help develop caliper. Be sure to remove temporary branches regularly, before they exceed pencil size diameter. To maintain the tree form, remove branches that develop from the trunk several times throughout the year and cut the canopy back periodically to preserve the dense, rounded shape.

Figure 12. *H. paniculata* is the hydrangea most commonly trained as a standard.

H. quercifolia — Oakleaf Hydrangea

Oakleaf hydrangea is native to the southeastern U.S. and is hardy to USDA plant hardiness zone 5. Most cultivars reach 6 to 8 feet in height. Plant spread is greater than height as plants sucker from roots. Like most hydrangeas, oakleaf hydrangea benefits from light shade in the landscape but will tolerate full sun in the Southeast and Mid-Atlantic regions if given ample moisture. They are subject to root rot if overirrigated or placed in poorly drained soil. Oakleaf hydrangea flowers in early to midsummer. Flowers are large, white to cream-colored panicles and may turn pink to rose as they age, depending on the cultivar and location (Figure 13). Inflorescences are composed of a mixture of large, sterile and small, fertile flowers.

Figure 13. Many *H. quercifolia* flowers age to an attractive rose color.

Propagation. *Hydrangea quercifolia* is the most difficult of these species to root. Terminal cuttings collected as green wood or firm wood treated with 4,000 ppm IBA quick dip or talc root well in five to six weeks (Figure 14). Untreated cuttings do not root in high percentages. A well-drained propagation substrate such as 100 percent

Figure 14. *H. quercifolia* cuttings treated with 4,000 IBA root readily.

perlite or 3 perlite : 1 peat and intermittent mist must be used. Following rooting, take precautions not to overirrigate. Rooted cuttings should not be disturbed in order to increase survival. Additionally, rooted liners must be overwintered in a cool environment, not a greenhouse, to increase the survival rate. Semi-hardwood cuttings should be treated with 2,500 ppm IBA.

Production. Oakleaf hydrangea is not as easy to grow in a container as the previously mentioned hydrangea species. The following production schedule has been used successfully (adapted from Halcomb et al., 2013): Surface sow seeds into trays in September-November. Transplant seedlings into 36-inch cell flats when the seedlings develop the second pair of true leaves. Keep seedlings on the dry side. Transplant seedlings into jumbo 5 ¼-inch pots, pinching to leave two nodes to force branching. Transplant into #3 containers when the roots fill the 5-inch containers. Prune any vigorous lateral branches that are stimulated after the pinching. Plants partially fill a #3 container by mid- to late April but are not large enough to sell. If the seedlings go into #1 from the 36-cell pack and they are grown with heat in a greenhouse all winter, #1 containers can be ready to sell by late April. Transplanting the seedling straight into a #1 container or the 36-cell pack straight to a #3 can lead to the small plants staying too wet and developing root rot.

In studies at the UT Institute of Agriculture in Knoxville, individual 4-inch 'Alice' liners transplanted into #3 containers were ready for retail sales in four months. Plants tolerate full sun in production if given adequate irrigation. Dieback has been reported after shearing in the Midwest and Southeast. It was not clear if dieback occurred because the plants were using much less water than other plants in the irrigation zone and were, thus, overwatered or some other cause. Oakleaf hydrangea appears to be the least "water loving" hydrangea species. Air pruning containers, containers with openings in the sidewalls, have been employed successfully in nurseries to reduce the chance that plants are too wet. This can be an especially helpful technique when oakleaf hydrangea must be grouped in an irrigation zone with other plants that require more water. To conserve water, place plants in either their own zone or the same irrigation zone as plants with similar water needs.

Nutrient management. There is little research on nutrient response of *H. quercifolia*. Oakleaf hydrangea 'Alice' plants mentioned in the Irrigation section were fertilized with a controlled release fertilizer at the medium rate (10 grams actual nitrogen). Therefore, fertilize *H. quercifolia* with a controlled release fertilizer at the medium rate with fertilizer longevity matched with crop production cycle and assess quality and growth.

Irrigation. When in the same irrigation zone as more water-loving plants, *H. quercifolia* can be potted in containers with porous sidewalls or a coarser substrate with greater porosity to help prevent the roots from staying too wet. In a study comparing daily water use with on-demand irrigation schedules, plants irrigated according to the on-demand schedule received 0.31 gallons and 0.12 gallons of water on average per day for #3 and #1 containers, respectively. Both the on-demand and daily water use irrigation schedules used less water than a 1-inch per day conventional irrigation schedule. In #3 containers, water use was reduced by 63 and 56 percent for on-demand and daily water use, respectively, and 57 and 36 percent for on-demand and daily water use, respectively, in #1 containers.

Pruning. *Hydrangea quercifolia* flowers on old wood, so prune after flowering, if necessary. Pruning in the late summer or fall through bloom time the following year will remove potential buds. *Hydrangea quercifolia* can have a very undesirable, asymmetrical growth habit, with most branches lying over the side of the container, although newer releases such as the USDA releases 'Ruby Slippers' and 'Munchkin' are much more compact and symmetrical in their growth habit (Figures 15a and b). The typical branch architecture is highly undesirable as it takes up more space in production and transportation and doesn't display well in garden centers. In a study comparing tissue culture and cutting propagation, 'Alice' oakleaf hydrangea plants propagated by tissue culture had greater quality rating and, depending on year, more branches. Cutting-propagated plants needed to be pruned to achieve the same quality. As with all hydrangeas, keep plants well-spaced.

Figures 15a and b. (a) New releases like 'Ruby Slippers' are much more compact and lend themselves to rack shipping; (b) *H. quercifolia* can be lanky and asymmetrical in a container and require repeated pruning to make a densely branched plant.

In summary, hydrangea are a significant nursery crop and can be grown profitably in the southern and mid-Atlantic states. With relatively few inputs and moderate irrigation management, hydrangeas are ready for sale within a year from propagation. Hydrangea species have tremendous marketing potential since they are adaptable to almost any landscape setting and among the popular species, flower from spring through fall in a range of colors. Whether it's a native oakleaf or Asian bigleaf hydrangea, hydrangeas hold an irreplaceable and growing part of our culture and landscape.

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