Four Sterile or Near-sterile Cultivars of Japanese Barberry in Three Foliage Colors

Mark H. Brand and Shelley N. Durocher
Department of Plant Science and Landscape Architecture, University of Connecticut, 1376 Storrs Road, Storrs, CT 06269-4067

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Berberis thunbergii L. (Japanese barberry) holds significant market share in the commercial ornamental horticulture industry. Japanese barberry is grown by production nurseries and used in landscaping across the northern half of the United States. In 2009, the barberry crop was worth nearly $30.5 million in annual sales in the United States, making it one of the top two ornamental shrubs, roses excluded. [U.S. Department of Agriculture (USDA) 2009]. Dirr (2009) lists close to 70 cultivars of B. thunbergii or B. thunbergii hybrids, and new cultivars continue to be introduced at a rapid rate. Hardiness, ease of culture, resistance to deer browse, compact habit, and general attractiveness have made Japanese barberry one of the most popular landscape shrubs in the United States (Steffey, 1985). Japanese barberry cultivars offer ornamental interest in all four seasons, featuring yellow flowers in spring; attractive red, yellow, green, or variegated foliage in summer; leaves that turn orange, yellow, and red in fall; and bright red berries that persist through the winter (Steffey, 1985). Its thorny stems make it useful as an impenetrable hedge in home landscapes (Steffey, 1985), and other uses include foundation plantings, groupings, and even as a specimen for difficult growing conditions (Dirr, 2009). Japanese barberry’s popularity as a commercial horticulture staple crop has also resulted from its ease of culture under production nursery conditions (Mark Seliew, Prides Corner Farms, Lebanon, CT, personal communication). Barberry roots easily from cuttings; thus, large numbers of genetically uniform plants may be raised (Dirr and Heuser, 2006), and it only requires one to two growing seasons to reach saleable size in a container.

Berberis thunbergii is a shrub native to Japan that was introduced into the United States in 1875 through the Arnold Arboretum in Boston (Silander and Klepeis, 1999). By the early 1900s the plant was being promoted and marketed as a replacement for common barberry (Berberis vulgaris), a shrub long cultivated in the United States until an eradication campaign was mounted in the 1920s because the species serves as an alternate host for a destructive grain rust (Silander and Klepeis, 1999). From initial introduction sites in Boston and New York, Japanese barberry showed up by the 1920s as a garden escape in rural areas of Massachusetts and New Hampshire, and by the 1960s it was recognized as a serious invader of many habitat types throughout the northeastern United States (Silander and Klepeis, 1999). The USDA (2011) reports that Japanese barberry is naturalized within more than 30 states, including areas of the Midwest and adjacent Canada. It appears that the introduction of this plant is only limited by cold hardiness factors and its need for cold stratification to prompt successful seedling germination (Silander and Klepeis, 1999).

Many of the characteristics that make Japanese barberry a desirable landscape shrub also predispose it to be an invader. Japanese barberry produces large quantities of red berries that mature in September and contain one to three seeds (Dirr and Heuser, 2006; Ehrenfeld, 1999). Brand et al. (2012) found that many cultivars of Japanese barberry can produce several thousand seeds annually as mature plants, which will lead to establishment of hundreds of seedlings each year in unmanaged areas. Japanese barberry is also adaptable and can colonize many habitat types, including closed forests, woodlands, wetlands, meadows, pastures, fence rows, waste places, among others (Lubell and Brand, 2011; Silander and Klepeis, 1999).

Concern over the detrimental ecological effects of invading Japanese barberry has prompted many states to ban the sale of this species. Maine (Maine Department of Agriculture, Conservation & Forestry, 2021), Massachusetts (Massachusetts Department of Agricultural Resources, 2021), Minnesota (Minnesota Department of Natural Resources, 2021), New Hampshire (New Hampshire Department of Agriculture, Markets & Food, 2017), New York (New York State Department of Environmental Conservation, 2021b), and West Virginia (West Virginia Department of Agriculture, 2021) have passed laws that prohibit the sale of B. thunbergii. Minnesota has allowed continued sale of B. thunbergii cultivars that produce reduced numbers of seeds and New York has allowed for exemptions of cultivars that meet low fecundity standards (New York State Department of Environmental Conservation, 2021a).

Use of native species, or noninvasive exotic species, as alternatives to invasive species has had some success. However, it is difficult to identify replacement plants that match the ornamental characteristics and landscape performance traits that Japanese barberry provides. For these hard-to-replace invasive species, there is considerable industry interest in the development of sterile forms of these plants (Gagliardi and Brand, 2007). Development of sterile, or near sterile, cultivars of B. thunbergii provides the nursery and landscape industries with plants that can be used in the same way that existing cultivars are used, without the environmental risk. Using polyploidy breeding, four sterile or nearly sterile, compact cultivars of B. thunbergii were created with red foliage, yellow foliage, or green foliage.

Origin

Creation of ‘UCONNBTCP4N’ was initiated in 2004 by exposing in vitro shoot cultures of Berberis thunbergii ‘Crimson Pygmy’ (syn. Berberis thunbergii ‘Atropurpurea Nana’) to the mitotic inhibitor colchicine to create an autotetraploid form of the plant. No paternal plant was involved in the creation of ‘UCONNBTCP4N’. Methods used to produce tetraploids in vitro are similar to those described by Lehrer (2007) for Berberis thunbergii var. atropurpurea. Briefly, nodal explants of in vitro Berberis thunbergii ‘Crimson Pygmy’ shoot cultures were exposed to 0.1% colchicine for 24 h in liquid culture media. Nodes were then grown out in tissue culture and shoots were segregated into individual shoots and cultured further to eliminate any potential mitoxplody. Ploidy of individual shoot cultures was then determined by flow cytometry using methods described by Anumanganathan and Earle (1991) and modified by Lehrer et al. (2008). Flow cytometry was conducted using a BD Accuri C6 Flow Cytometer (BD Biosciences, San Jose, CA) and data were analyzed using the BD Accuri C6 Flow Cytometer software. Standard diploid ‘Crimson Pygmy’ and tetraploid var. atropurpurea histogram peaks were compared with unknown samples. A shoot confirmed as tetraploid was then multiplied in vitro and microshoots were rooted in vitro and acclimated to the greenhouse. Thirty tetraploid plants derived from ‘Crimson Pygmy’ were produced in 2005 and grown in a greenhouse and coldframe during the first growing season. For the 2006 through 2010 growing seasons, plants were grown in containers outdoors and evaluated for horticultural traits and fruit and seed production. Container plants were overwintered in an unheated white polyethylene covered hoop house during each winter dormancy. In Spring 2011, plants were installed in the field for long-term evaluation and were evaluated annually for horticultural performance and seed production through 2021. Tetraploidy was
confirmed by flow cytometry five times on plants outside of in vitro culture; twice in the first year, once in year two, once in year three, and once in year five. ‘UCONNBTCP4N’ was selected for introduction based on lack of seed production over a period of 16 years, in combination with compact, dense form and attractive red foliage color.

‘UCONNBTB048’ and ‘UCONNBTB113’ were developed by exposing pregerminated, open pollinated seed of *B. thunbergii* ‘Bogozam’ Bonanza Gold® to the mitotic inhibitor colchicine to create autotetraploid plants. Specific methods used followed those published by Lehrer et al. (2008). Briefly, seeds were cold stratified for 5 weeks during Winter 2007 and then pregerminated, so 5 to 7 mm of radicle was emerged from the seeds. Pregerminated seeds were then exposed to a 0.1% colchicine solution for 24 h. Treated seeds were planted in flats and grown in a greenhouse until they were large enough for ploidy analysis by flow cytometry as described for ‘UCONNBTCP4N’.

Thirty seedlings from ‘Bogozam’ were confirmed as tetraploids and were grown on for evaluation of horticultural traits and seed production. Tetraploid plants were grown in a greenhouse and outdoor coldframe for their first growing season and then outdoors in containers during 2008, 2009, and 2010. In Spring 2011, 10 of the tetraploid plants that exhibited bright yellow foliage, good ornamental characteristics, and no seed production as container plants were planted in the field for long-term evaluation as mature plants. Three diploid *B. thunbergii* var. *atropurpurea* plants were grown in the same planting as tetraploid plants to serve as control plants. During the growing seasons from 2011 to 2021, tetraploid plants established in the field were evaluated for horticultural performance and seed production in comparison with diploid control plants. *B. thunbergii* ‘UCONNBTB039’ was selected from among the 10 tetraploid seedlings installed in the field based on lack of seed production, vigorous growth, compact habit, and spreading form. Green foliage was also a selection consideration to provide an additional leaf color offering in sterile Japanese barberry, along with red and yellow. Tetraploidy was confirmed multiple times by flow cytometry when plants were in containers and the field.

### Descriptions

The following observations, measurements and values describe plants grown during the spring, summer, or fall in ground beds or containers in an outdoor nursery in Storrs, CT, and under cultural practices that closely approximate commercial barberry production. Plants used for description and for most photographs were 10 years old. Detailed descriptions of color for plant parts was based on comparison with the Royal Horticultural Society (RHS) Colour Chart (Royal Horticultural Society and Flower Council of Holland, 1986).

‘UCONNBTCP4N’. Plants of ‘UCONNBTCP4N’ are low, dense, and mounded with many branches, typically being wider than tall (Figs. 1 and 2). Plants will be 45 to 60 cm tall and 90 to 105 cm wide in 10 years. New stems are yellow-green (RHS 146D), firm and stiff with a 2- to 3-mm diameter. Annual shoot growth is between 10 and 20 cm with 10 to 20 mm internodes. Single, slender, 10- to 12-mm thorns are found at most nodes and have color changing from 146D at the base to 138B at the tip. Leaves are alternate down long shoots and whorled in rosettes on spur shoots, usually with two to three leaves at each node. Leaves are simple, glabrous, and valued by gardeners for their attractive foliage color and seed production in comparison with diploid control plants. During the growing seasons from 2011 to 2021, tetraploid plants established in the field were evaluated for horticultural performance and seed production in comparison with diploid control plants. *B. thunbergii* ‘UCONNBTB039’ was selected from among the 10 tetraploid seedlings installed in the field based on lack of seed production, vigorous growth, compact habit, and spreading form. Green foliage was also a selection consideration to provide an additional leaf color offering in sterile Japanese barberry, along with red and yellow.

Fig. 1. *Berberis thunbergii* ‘UCONNBTCP4N’. (A) Looking up into the corolla of the flowers. (B) Looking at the red sepals on the backs of the flowers. (C) New spring foliage just as long shoot growth is beginning. (D) Container-grown 1-gallon plants at the beginning of their second summer of growth since propagation. These plants were rooted from softwood cuttings two summers earlier. (E) A field grown plant in spring. (F) A field-grown plant in summer.
obovate to spatulate-oblong and 20 to 50 mm long and 14 to 21 mm wide with entire margins and pinnate venation (Fig. 3). The adaxial surface of developing leaves in high light conditions is greyed purple (RHS 183A and 183B) and the abaxial surface is greyed purple (RHS 186A) at the margins, changing to greyed green in the center. The adaxial surface of fully expanded leaves in high light conditions is greyed purple (RHS 187A) and brown (RHS 200A) and the abaxial surface is greyed purple (RHS 191A). Shaded leaves are green (RHS 137A) on the adaxial surface and (RHS 137C) on the abaxial surface. Petioles range from 1 to 14 mm long with a 1-mm diameter and colors match the lamina.

Inflorescences are cymose, with a diameter of 21 to 25 mm and a length of 10 to 20 mm and contain two to four flowers. Flowering occurs in April (Storrs, CT) and flowers persist for 7 to 14 d depending on weather conditions. Individual flowers are 5 to 7 mm long and 10 to 13 mm in diameter and comprised of a single whorl of six petals and single whorl of six to eight sepals. Petal color is yellow (RHS 12C) and sepal colors are yellow (RHS 12C) on the adaxial surface and red (RHS 53A and 53B) on the abaxial surface. Peduncles are 4 to 14 mm long and pedicels are 4 to 6 mm long; both are red (RHS 53A and 53B). Fruits are seldom produced but are 8 to 11 mm long and 4 to 5 mm in diameter ellipsoidal berries that ripen in October with a red color (RHS 53B).

‘UCONNBTBO39’. Plants of ‘UCONN-BTBO39’ are low, dense, and mounded with many spreading and overarching branches, typically being wider than tall (Fig. 4). Plants will be ≈70 cm tall and 120 cm wide in 10 years. New stems are yellow-green (RHS 146C), changing to brown (RHS 200B) as the growth hardens, becoming firm and stiff with a 2- to 3-mm diameter. Stems older than two seasons are brown (RHS 200B) and black (RHS 199D). Annual shoot growth is between 10 and 20 cm with 10- to 20-mm internodes. Single, slender, 9- to 10-mm, yellow-green (RHS 146D) thorns are found at most nodes. Leaves are alternate down long shoots and whorled in rosettes on spur shoots, usually with two to four leaves at each node. Leaves are simple, glabrous, obovate to spatulate-oblong and 20 to 40 mm long and 15 to 23 mm wide with entire margins and pinnate venation (Fig. 3). The adaxial surface of developing leaves in full sunlight conditions is yellow (RHS 6A to 6C, 7A to 7C, and 10A) and the abaxial surface is yellow (RHS 10B to 10D). The new growth has a red coloration (RHS 43A) visible for a period at the leaf margin. Under full sunlight conditions, the adaxial surface of fully expanded shaded leaves on the interior of the plant ranges from green to yellow-green (RHS 141A through 144A), whereas leaves on the outside of the plant receiving full sunlight are yellow (RHS 11A–11D). The abaxial surface of fully expanded leaves is yellow (RHS 11B through 11D) under full sunlight exposure, but green (RHS 138B) for shaded interior leaves. Petioles range from 1 to 12 mm long with a 1 mm in diameter and upper and lower surface colors of yellow (RHS 12C).

"Fig. 2. Fruiting of Berberis thunbergii ‘UCONNBTCP4N’ compared with Berberis thunbergii ‘Crimson Pygmy’. (A) Intact ‘Crimson Pygmy’ fruits left, ‘UCONNBTCP4N’ fruits right. (B) Cut open ‘Crimson Pygmy’ fruits left showing developed seed, ‘UCONNBTCP4N’ fruits right showing aborted, necrotic embryos. (C) A single ‘Crimson Pygmy’ plant in November in Mansfield, CT, showing copious fruit production and two plants of ‘UCONNBTCP4N’ showing no fruit production.

Fig. 3. Comparison of leaves from each sterile Berberis thunbergii cultivar with leaves from the respective maternal parent genotype. (A) ‘UCONNBTCP4N’. (B) ‘Crimson Pygmy’. (C) ‘UCONNBTBO39’. (D) var. atropurpurea. (E) ‘UCONNBTBO48’. (F) ‘UCONNBTB113’. (G) ‘Bogozam’. Ruler divisions are 1 mm."
Inflorescences are cymose, with a diameter of 21 to 25 mm and a length of 10 to 20 mm and contain three to six flowers. Flowering occurs in April (Storrs, CT) and flowers persist for 7 to 14 d depending on weather conditions. Individual flowers are 5 to 7 mm long and 10 to 13 mm in diameter and comprise a single whorl of six petals and single whorl of six to eight sepals. Petal color is yellow (RHS 12C) and sepals are yellow (RHS 12C) on the adaxial surface and red (RHS 43A and 43B) on the abaxial surface. Peduncles are 4 to 14 mm long and pedicels are 4 to 6 mm long; both are yellow-green (RHS 154B). Fruits are seldom produced but ripen in October, are elliptical, 8 to 10 mm long, and 4 to 5 mm in diameter with a red color near RHS 53B.

Evaluation of Male Fertility

Male fertility was only assessed for ‘UCONNBTC4N’. Viability of pollen from three diploid ‘Crimson Pygmy’ plants and 10 ‘UCONNBTC4N’ plants were compared. Acetocarmine staining was used to evaluate structural soundness of pollen and in vitro germination was used to evaluate pollen viability. Sixteen open flowers were collected from each of the 13 plants between 7 and 9 AM and immediately brought to the laboratory for pollen collection. Whole flowers were placed in 60-mm glass petri dishes held at a slight incline and 2-mL of n-pentane was added to each dish to release the sticky pollen inherent to Berberis spp. from the anthers (Cadic, 1992). For each plant sampled, 12 flowers were used for in vitro germination and four flowers were used for acetocarmine staining. Flowers were soaked in the n-pentane solution for ≈1 min, after which time

Inflorescences are cymose, with a diameter of 18 to 25 mm and a length of 8 to 18 mm and contain three or four flowers. Flowering occurs in April (Storrs, CT), and flowers persist for 7 to 14 d depending on weather conditions. Individual flowers are 3 to 6 mm long and 8 to 12 mm in diameter and comprise a single whorl of six petals and single whorl of six to eight sepals. Petal and sepal color is yellow (RHS 154B). Fruits are seldom produced but ripen in October, are elliptical, 8 to 11 mm long, and 4 to 5 mm in diameter with a red color near RHS 53B.
Table 1. Seed production of *Berberis thunbergii* ‘UCONNBTCP4N’ (n = 30), ‘UCONNBTB039’ (n = 1), ‘UCONNBTB048’ (n = 1), ‘UCONNBTB113’ (n = 1) and ‘Crimson Pygmy’ (n = 6) over 16 growing seasons from 2006 to 2021, initially as container-grown plants and then as field grown plants.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Containers</th>
<th>Field planting</th>
</tr>
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<tbody>
<tr>
<td>UCONNBTCP4N</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>UCONNBTB039</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>UCONNBTB048</td>
<td>NA*</td>
<td>NA</td>
</tr>
<tr>
<td>UCONNBTB113</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Crimson Pygmy</td>
<td>NC7</td>
<td>NC</td>
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</tbody>
</table>

*NA indicates that plants were not available in these years.

*NC indicates that seeds were not counted in these years.

Each flower was held by the pedicle with forceps, swirled in solution to facilitate pollen grain release, and finally removed and discarded. The n-pentane solution was allowed to volatilize leaving only the pollen grains in the petri dish. The inclination of each dish caused the pollen grains to settle in a confined area, which allowed for the use of less solution to resuspend all grains collected.

For acetocarmine staining, 45 μL of 0.5% acetocarmine stain was added to the petri dish and pipette-mixed to suspend pollen in stain solution. The 45 μL of stain containing suspended pollen was then transferred to a standard microscope slide and heated 3 times for 5 s each over a hot plate set to low. A cover slip was applied, and the preparation was allowed to incubate at room temperature (23 °C) under ambient light for 30 min. Stained pollen grains were observed on a compound microscope under 100× magnification. Microphotographs were taken of pollen grains counted. Humidity chambers were provided every opportunity to outcross with both diploid and tetraploid genotypes, so self-incompatibility and incompatibility of ploidy types should not be the cause of observed low seed set. Six plants of the fertile diploid ‘Crimson Pygmy’ were interplanted directly among the ‘UCONNBTCP4N’ plants.
under evaluation to serve as a known fertile control genotype.

Each year in October, as fruit became fully ripe, fruits were harvested from the evaluation plants and seeds were extracted and counted. The small number of seeds that were produced on ‘UCONNBTP4N’ and ‘UCONNBTB039’ were cleaned and mixed with damp sand and cold stratified for up to 90 d at 42 °F in plastic baggies. Following stratification, seeds were sown, and germination was evaluated. Germinated seedlings were grown out and flow cytometry was conducted to determine the ploidy of the seedlings.

During the early evaluation period, when plants were initially grown in containers, tetraploid genotypes were found to vary dramatically in their female fertility. Most tetraploids exhibited significantly reduced seed production in comparison with diploids. Tetraploids varied from producing no seeds to more than 200 seeds per plant. Genotypes that produced seeds in containers were discarded and only seedless genotypes were carried forward.

All four new cultivars were sterile or near sterile over the study period from 2006 to 2021 (Table 1). ‘UCONNBTP048’ and ‘UCONNBTP113’ did not produce any seeds during the entire evaluation period. In most years, ‘UCONNBTP039’ produced no seeds, but there were 2 years, 2012 and 2013, when one seed per plant was observed. ‘UCONNBTCP4N’ did not produce seeds in 13 of 16 years but did produce 1.5 or fewer seeds per plant in 3 years.

These are extremely low seed production numbers for Japanese barberry. Fertile ‘Crimson Pygmy’ plants interplanted with sterile genotypes under evaluation produced between 622 to 886 seeds per plant depending on the year, with an average of 736 seeds per plant per year over a 5-year period (Table 1). Brand et al. (2012) reported that ≈6-year-old fertile var. atropurpurea produced 1179 seeds per plant per year and fertile ‘Bogozam’ produced 141 seeds per plant per year. Many fertile Japanese barberry cultivars have been shown to produce several thousand seeds per plant per year as ≈6-year-old plants. Brand et al. (2012) estimated establishment rates for many Japanese barberry cultivars using cumulative 2-year seed germination values and seedling survival rates in a woodland setting. Using the predicted seedling establishment rate of 0.026 for ‘Crimson Pygmy’ (Brand et al., 2012), we can estimate that our sterile cultivar ‘UCONNBTCP4N’ can be expected to produce between 0 and 0.04 seedlings to a woodland area each year. Establishment of seedlings from ‘UCONNBTB039’, ‘UCONNBTB048’, and ‘UCONNBTB113’ in a woodland would be even lower than for ‘UCONNBTCP4N’. Limited germination testing showed that some of the seeds from sterile cultivars could germinate and grow into seedlings. Recovered seedlings were found to be tetraploids.

**Black Stem Rust Resistance Testing**

Plants were tested at the USDA-Agricultural Research Service Cereal Disease Laboratory in St. Paul, MN, in 2016 and again in 2021 for susceptibility to black stem rust (BSR) of wheat. Plants with soft, new shoot growth were inoculated with germinating teliospores of _Puccinia graminis_ when the new leaves were deemed to be receptive for infection by the stem rust pathogen. _Berberis vulgaris_ and _B. chinensis_ were used as positive rust susceptible controls and tests were only considered adequate when these two species developed heavy infections with _pycnia_ and _aecia_ in the same challenge experiment. A total of 12 plants and 24 tests were conducted on ‘UCONNBTCP4N’, 14 plants and 27 tests on ‘UCONNBTB039’, 13 plants and 26 tests on ‘UCONNBTB048’, and 14 plants and 25 tests on ‘UCONNBTB113’. All tests showed that the four genotypes of barberry were immune to infection by _P. graminis_, and the genotypes were deemed to be resistant to BSR. On 5 Sept. 2017, all four genotypes were added to the Federal Register list of rust-resistant _Berberis_ and _Mahonia_ seedless species and varieties (USDA Animal and Plant Health Inspection Service, 2017).

**Propagation**

Vegetative propagation can be accomplished using softwood cuttings in a way that is similar to commercial propagation of other Japanese barberry cultivars. Semifirm cuttings should be taken in late June through mid-July (Connecticut), given a basal dip in 3000 to 5000 ppm indole-3-butyric acid, and stuck in 75% sand:25% peatmoss. Intermittent mist irrigation values and seedling survival rates remain true-to-type over successive generations of asexual propagation. The sterile cultivars should be used, but must be kept to as minimal an amount as possible. The sterile cultivars are somewhat more difficult to root than many existing _B. thunbergii_ cultivars, probably due to their polyploid nature. Over three rooting seasons, ‘UCONNBTCP4N’ rooted at 45% to 66%, ‘UCONNBTB039’ rooted at 72% to 84%, ‘UCONNBTB048’ rooted at 60% to 78%, and ‘UCONNBTB113’ rooted at 43% to 63%. Rooted cuttings overwinter without significant losses and grow out well the following spring. Plants propagated by cuttings retain their unique features, are stable, and remain true-to-type over successive generations of asexual propagation.

**Conclusion**

Japanese barberry cultivars have been popular landscape plants because they are easy to produce, perform well in many challenging landscape situations, are resistant to deer browse, have compact habits, and come in different forms with red, yellow, or green summer foliage. Existing cultivars have been documented to be too fecund, are highly invasive, and their use has been discouraged or made illegal. The new cultivars ‘UCONNBTCP4N’, ‘UCONNBTB039’, ‘UCONNBTB048’, and ‘UCONNBTB113’ are compact; come in red, green, and yellow foliage forms, are essentially seedless, are not invasive, and can be safely used for landscaping purposes. In addition, the four new cultivars are all resistant to black stem rust and do not put wheat crops at risk.

**Availability**

The four sterile genotypes of _Berberis thunbergii_ were licensed exclusively to SynRG, an independent retail-grower collaboration. As a group, the four cultivars are marketed as WorryFree® plants in recognition of their sterile condition. All four cultivars have been patented by the University of Connecticut–Farmington as follows: ‘UCONNBTCP4N’ (PP30,095), ‘UCONNBTB039’ (PP30,128), ‘UCONNBTB048’ (PP30,127), and ‘UCONNBTP113’ (PP30,094). ‘UCONNBTCP4N’ holds the trade name of Crimson Cutie®, ‘UCONNBTB039’ holds the trade name of Mr. Green Genes®, ‘UCONNBTB048’ holds the trade name of Lemon Glow®, and ‘UCONNBTB113’ holds the trade name of Lemon Cutie®.

**Literature Cited**


