Regional and Preliminary Reports

Selection of Willows for Floral and Stem Quality and Continuous Production Sequence in Temperate North America

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Additional index words. pussy willows, alternative field crop, florist cut stems, *Salix*

Summary. **The study addresses the problem of diversification and quality of willow (*Salix*) cut stems. Very few ornamental willow species are currently in production for the cut-stem trade in temperate North America, and they have a relatively short annual harvest period. This study selected 20 taxa of willow with the potential for cut-stem industry based on observations of more than 150 taxa in central Ohio for 4 years. Growth and ornamental qualities of branches and inflorescences of those species, hybrids, or cultivars were measured and evaluated. The species range in hardiness from USDA zones 2 through 7, but the majority are best suited to zone 4 and 5 conditions. Specific descriptions of each species are provided, focusing on those details important for the floral industry including stem length, bark and bud colors, catkin color and quality, optimal harvest time, and the sequence of bloom among species. Stems for catkin display can be harvested and marketed from January through April. Branches used for bark and bud color displays and for stem shape have an even longer harvest period. New selections provide a greater range of stem size, catkin characteristics, bark and bud color, and prolonged harvest period, than commonly used pussy-willows.**

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Salaries and research support provided in part by State and Federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University.

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The production of woody branches for the specialty cut flower market has wide-ranging potential considering the large number of species useful for cut purposes (Armitage, 1993). Ornamental branches for mid-winter through early spring harvest, when other flowers are scarce, expensive, and shipped from distant sources, can be a unique production niche for small farmers and non-agricultural land-owners, offering an opportunity to supplement income during the otherwise dormant season. Willow production is sustainable for many years from initial planting, and requires basic input based on organic principles. Willows are tolerant of relatively poor soil, marginal or poorly drained agricultural land, can be grown on small or odd land configurations, or areas contaminated with certain pollutants and not suitable for other crops (Newsholme, 1992; Stott, 1992). Woody cuts from other shrubs [e.g., forsythia (*Forsythia* sp.), quince (*Chaenomeles* sp.), and lilac (*Syringa* sp.)] can also be forced for early floral display, but willow branches are additionally valuable to the floral industry for stem structure and length, bark and bud color and texture, catkin longevity, amenability to a long period of winter forcing and for lower production and shipping costs than other floral crops. Willows are reliable and more durable than other shrubs, with low susceptibility to winter damage or spring frost, and a comparatively reduced risk of premature blooming. In Europe, flowering branches of willow [goat willow (*Salix caprea*) and gray willow (*S. cinerea*) in England (Bean, 1970); sharp-leaf willow (*S. acutifolia*) in Russia)] are in high demand for spring holidays, and dried pussy-willow stems are used throughout the year in fresh and artificial bouquets. Pussy-willows [usually goat willow and american pussy willow (*S. discolor*)] are equally popular in the United States, and have long been a staple component of spring bouquets. However,there are many worthwhile species and cultivars (Smith, 1978; Vernon, 1997) that have not been promoted in the trade.

The objectives in this study were to select a group of North American and newly introduced Eurasian shrub willows for desirable stem and catkin qualities based on the observational studies. The goals were to evaluate willows for ornamental vegetative and flowering characteristics and present the horticultural attributes of superior taxa. Additionally, we wished to document the relative phenological sequence of these 20 species over several years, to produce a schedule for continuous winter/spring harvest in temperate North America, including the United States and Canada.

Materials and methods

More that 150 willow taxa were procured from nurseries, botanical gardens, and private collections (Kuzovkina, 2003), as unrooted cuttings and grown outdoors for 4 years at the Ohio State University Chadwick Arboretum, Columbus, and at the Waterman Agricultural Laboratory, Columbus, Ohio, USDA zone 5, with an average annual precipitation through the period of study (1999–2002) totaling 88.2 cm (34.72 inches), average high temperature of 17.7 °C (63.86 °F) and average low tempera-

ture of 6.4 °C (43.52 °F). Field soil was Crosby silt-loam. Plants received supplemental irrigation during the first year after planting to assist them to establish root systems, but were not subsequently irrigated. An annual topdressing of shredded bark mulch for weed control at the stem bases was administered annually.

The selection was based on observations following a concise evaluation of numerous species. The selection criteria included production of abundant catkins with fuzzy "pussy-willow" effect and stems with bright colors or ornamental configuration. We quantified the annual growth of coppiced specimens (in terms of harvestable stem length), measured and described floral and vegetative characteristics (stem color or shape, bud color and density, catkin size, color, texture, and relative location on the stem) of selected willows over a period of 4 years. Floral characteristics were noted throughout the year as appropriate, and weekly during flowering. We verified plant identity at the level of species and cultivar, since considerable taxonomical confusion was prevalent in many germplasm sources. Scientific names are reported according to Argus (1997) and Skvortsov (1999).

Results and discussion

VEGETATIVE AND FLOWERING CHARACTERISTICS. We selected 20 species and cultivars from North American and Eurasian origins that appear to be desirable for the floral industry. We found a wide range of ornamental characteristics in willows not commonly available, though fully hardy in the upper midwestern United States (Table 1).

Table 1. Horticultural characteristics of 20 shrubby willows suitable for temperate North American cut stem production. All measurements, the averages of 4 years of data, refer to typically well-developed shoots at the end of one growing season following autumn coppicing.

Common name	Species name (synonyms); source	USDA zone	Ultimate size (m)[z]	Stem length (m)	Stem color	Flower bud color	Catkin color; size (mm)[y]	Origin	Notes
Sharp-leaf willow	*S. acutifolia*; MBG[x]	4–6	6.0 × 4.0	1.2–1.6	Red (44B)[w]	Red (44B) shiny; 20 × 12	Light gray (156C),	Eastern Europe	Dense prolific catkins, excellent for floral display, unique for purple stems. Drought tolerant, sandy soil.
Armenian willow, musk willow	*S. aegyptiaca* (*S. medemii*, *S. muscina*); MBG	5–7	8.0 × 4.0	0.6–0.8	Gray (201D)	Light brown (N200D)	Gray (201D), not shiny, 20 x 9	Eurasia	Prolific catkins and very early bloomer; green bracts at base of catkins
None	*S. amplexicaulis*. (*S. purpurea* 'Amplexicaulis'); MBG	5–7	4.0 × 4.0	0.7–0.8	Dark purple-red (63A)	Deep red (52A) not shiny; 12 × 4	Dark gray (201B),	Central Europe	Thin flexible stems; catkins unremarkable until anthers mature orange or deep red
Corkscrew willow	*S. babylonica* 'Tortuosa' (*S. matsudana* 'Tortuosa'); Lake County Nursery (Perry, Ohio)	5–7	10.0 × 6.0	1.5-2.0	Brown-yellow (18B)	Brown (59B)	Not showy	Eastern Asia	Several cultivars common in trade differ by stem color [*S.* × 'Scarcuzam' ('Scarlet Curls'), *S.* 'Golden Curls', *S.* 'Snake' and *S.* x*sepulcralis* 'Erythroflexuosa']
Goat willow, french pussy willow	*S. caprea*; Morton Arboretum (Lisle, Ill.)	4–7	10.0 × 5.0	1.5–2.0	Dark purple red (63A)	Dark) purple-red (63A	Grayish -white (156D), shiny; 15 × 8	Europe, Western Asia	Dense catkins; storage in dark cooler will promote pinker color. Hybrids and cultivars available.
American or common pussy willow	*S. discolor*; Oak Openings Preserve (Toledo, Ohio)	2–7 2.0	6.0 ×	0.7–1.0	Brown (59B)	Deep brown) (166A or black (202B)	Gray (201D), shiny; 12 × 6	North America	Catkins are not prolific. Very hardy shrub, but other species are superior for florist purposes.
Japanese pussy willow, or rosegold willow	S. gracilistyla; Forestfarm (Williams, Ore.)	5–7	3.0 × 1.5	1.5–1.8	Brown (59B)	Deep brown (166A)	Grayish-white (156D) shiny; 35 × 15	East Asia	One of the best species for catkin production; dries well and keeps for years.,
Black pussy willow	*S. gracilistyla* 'Melanostachys'; Klyn Nurseries (Perry, Ohio)	5–6	3.0 × 1.5	0.6–0.8	Dark purple-red (63A)	Dark purple-red (63A)	Deep black (202A); 20 × 8	Japan	Unique and showy by the color of its catkins.

Table 1 continued on next page.

Table 1. Continued.

Common name	Species name (synonyms); source	USDA zone	Ultimate size (m)[z]	Stem length (m)	Stem color	Flower bud color	Catkin color; size (mm)[y]	Origin	Notes
None	*S.* 'The Hague' (*S. hagensis*); Arnold Arboretum (Jamaica Plain, Mass.)	4–6	3.0 × 2.0	1.0–1.2	Gray (201D), green (142B)	Deep brown (166A)	Grayish-white (156D); 40 × 15	Europe	Female cultivar with large inflorescences and dense branched catkins clustered on the upper stems.
Hooker's willow, dune willow	*S. hookeriana*; MBG	4–6	3.0 × 3.0	0.6–0.8	Green (142B)	Red-brown (50A)	White (155D), woolly; 40 × 15	Western North America	Large white catkins, valuable for late production.
Prairie willow, small pussy willow	*S. humilis*; Oak Openings Preserve	4–6	2.0 × 2.0	1.2–1.5	Brown (59B) or green (142B)	Grayish –brown (199D)	Dark gray (201B); 10 × 4	Eastern North America	Small but dense catkins; anthers brick-red turning to yellow.
None	*S. koriyanagi* Kimura (*S. purpurea* var. *japonica*); Forestfarm	5–7	4.0 × 2.0	1.2–1.5	Yellow-green (151A)	Light brown (N200D)	Dark gray (201B); not shiny 20 × 5	Korea	Prolific dense catkins, and prolonged harvest time. Male catkins dark gray, female pink.
None	*S. kuznetzowii* Laksch.; MBG	3–6	3.0 × 1.5	1.2–1.5	Green (142A	Deep brown (166A)	Gray (201D); 25 × 12	Europe	More useful for accent twigs in floral design than for catkin display. Flower buds are stout and prolific.
Miyabe willow	*S. miyabeana*; Forestfarm	5–7	6.0 × 2.0	1.0–2.0	Yellow-green (151A)	Light brown (N200D)	Green (160A); curved, not shiny; 50 × 8	East Asia	Female catkins do not have effect of fuzziness but still can be used for arrangements. Males are not of interest for florists.
None	*S. schwerinii*; MBG	4–6	3.0 × 2.0	0.6–0.8	Dark purple-red (63A)	Deep brown (166A)	Gray (201D); shiny; 12 × 5	East Asia	Small catkins; good as filler for spring bouquet.
Japanese fan-tail willow	*S. udensis* 'Sekka' (*S. sachalinensi* 'Sekka'); Lake County Nursery	5–7	3.0 × 3.0	1.5–2.0	Mahogany (164B)	Brown (59B)	Grayish-white (156D); 15 × 5	East Asia	Stems flattened, curved or twisted. Not grown for catkins, but for stem architecture.
None	*S.* ×*friesiana* (*S. viminalis* × *S. repens*); Westonbirt Arboretum (Tetbury, England)	4–6	1.5 × 1.0	0.3–0.5	Brown (59B)	Brown (59B)	Grayish-white (156D); shiny; 15 × 5	Europe	Small delicate stems good for miniature floral arrangements.
None	*S.* ×*multinervis* (*S. cinerea* × *S. aurita*); Arnold Arboretum	4–7	4.0 × 2.0	1.0–1.2	Gray (156B)	Red-brown (50A)	Gray (201D); 30 × 6	Europe	Similar to *S.* ×*wimmeriana*. The latest species to develop.
None	*S.* ×*tsugaluensis* 'Ginme' (*S. integra* × *S. vulpina*); Morton Arboretum	5–7	2.0 × 2.0	1.2–1.5	Yellow-green (151A)	Red (28A), yellow tip (6A)	Light gray (156C), shiny, curved; 20 × 5	Japan	Bud scales are ornamental feature; dried stems retain color. Ornamental before and after budbreak.
None	*S.* ×*wimmeriana* (*S. caprea* × *S. purpurea*); Morton Arboretum	4–7	4.0 × 2.0	1.5–1.8	Yellow-green (151A)	Deep red (52A)	Light gray (156C); shiny 15 × 7	Europe	Ornamental for purple twigs with red bud scales. Female clone.

[z]1.0 m = 3.28 ft.
[y]25.4 mm = 1 inch.
[x]Moscow Botanical Garden (Moscow, Russia).
[w]Color number according to the Royal Horticultural Society color chart.

The willows we selected fall roughly into three categories of branch size. Seven species [armenian willow (*S. aegyptiaca*), *S. amplexicaulis,* american pussy willow, black pussy willow (*S. gracilistyla* 'Melanostachys'), hooker's willow (*S. hookeriana*), *Salix schwerinii* and *S.* ×*friesiana*] are "short," with harvest stem lengths averaging 1 m (3.3 ft) or less. Six species [*Salix* 'The Hague', prairie willow (*S. humilis*), *S. koriyanagi*, *S. kuznetzowii*, *S.* ×*multinervis*, *S.* ×*tsugaluensis* 'Ginme'] have medium stem length 1–1.5 m (4.9 ft). The rest of the species [sharp-leaf willow, corkscrew willow (*S. babylonica* 'Tortuosa'), goat willow, japanese pussy willow (*S. gracilistyla*), miyabe willow (*S. miyabeana*), japanese fan-tail willow (*S. udensis* 'Sekka'), and *S.* ×*wimmeriana*] have long stems, averaged about 1.5–2 m (6.6 ft).

Willow species were separated into the basic catkin color classes: white, gray, green and black. The color of catkins was determined by the color of the individual bracts, subtending a single flower, and particularly by the color of the bract hairs. The direction of the hairs on the inflorescence was important for light reflection, resulting in shiny effect when oriented the same direction (japanese pussy willow). In some species the bract hairs were multidirectional (e.g., *S. amplexicaulis* and hooker's willow) and the inflorescence was not shiny.

Willows were grouped based on the size of catkins into the following classes: small catkins [less than 15 mm (0.6 inch) long]: american pussy willow, prairie willow, *S. amplexicaulis* and *Salix schwerinii*; medium catkins [15–20 mm (0.8 inch) long]: armenian willow, black pussy willow, goat willow, japanese fan-tail willow, sharp-leaf willow, *S. koriyanagi*, *S.* ×*friesiana*, *Salix* ×*tsugaluensis* 'Ginme' and *S.* ×*wimmeriana*; and large catkins (>20 mm): hooker's willow, japanese pussy willow, miyabe willow, *Salix* 'The Hague', *S. kuznetzowii* and *S.* ×*multinervis.*

With most species (except miyabe willow and *Salix* 'The Hague') the male specimens were showier than females due to longer bract hair and larger catkin's size.

Some willows had nondescript catkins, but had high ornamental value for other characteristics such as attractively colored stems during winter, including green, mahogany, red, purple, or brown (e.g., corkscrew willow); stout, brightly colored buds (e.g., *S.* ×*tsugaluensis* 'Ginme'); stem shape (e.g., fantail willow).

PERIODS OF HARVEST. Willow flower buds form during the preceding year and their development continues throughout the winter (Newsholme, 1992). The bud scale abscises when the inflorescence expands in late winter or early spring and increases until reaching its maximum size. Shortly after this stage the catkin elongates, loses its density, and a noticeable differentiation of the anthers or pistils takes place, rendering it unsuitable for florist purposes. The length of the optimal harvesting period is the time

Table 2. Approximate schedule of willow stem harvesting in central Ohio (lat. 40°N), showing the extensive period that can be achieved by using an assortment of species. For those species meant for twig production (stems ornamental before budbreak), harvest time can be extended throughout dormant period from November until March. For phenological orientation in zones 5 and adjustment for other regions, several indicator species can be used: the second week of March (2 Mar.) corresponds to the beginning of corneliancherry dogwood (*Cornus mas*) flowering, the third week of March (3 Mar.) corresponds to the beginning of border forsythia (*Forsythia* ×*intermedia*) flowering and the second week of April (2 Apr.) to the beginning of flowering of flowering dogwood (*C. florida*), downy serviceberry (*Amelanchier arborea*) and eastern redbud (*Cercis canadensis*).

Species	Jan4	Feb1	Feb2	Feb3	Feb4	Mar1	Mar2	Mar3	Mar4	Apr1	Apr2
corkscrew willow											
Salix schwerinii											
armenian willow											
S. koriyanagi											
japanese pussy willow											
sharp-leaf willow											
S. amplexicaulis											
black pussy willow											
Salix 'The Hague'											
japanese fan-tail willow											
S. x*tsugaluensis*											
goat willow											
american pussy willow											
miyabe willow											
hooker's willow											
S. x*friesiana*											
S. x*wimmeriana*											
prairie willow											
S. kuznetzowii											
S. x*multinervis*											

between when the catkin reaches its maximum size and when stamens and pistils become visible. Those species valued for attractive branches (bark color or stem shapes) can be harvested any time from November through March, when high light intensity and cool temperature intensify coloration (Armitage, 1993).

To lengthen the market season, we recommend planting a series of species and/or cultivars. We found a considerable difference in time of bloom and the length of the optimal harvesting period among the described species (Table 2). The sharp-leaf willow can be harvested for only 1 or 2 weeks, while some other species (*S. koriyanagi*, japanese pussy willow) have a wider window for harvesting, lasting as long as 4 weeks. The precise timing of phenological phases can fluctuate from year to year depending on weather conditions, but the sequence of blooming and leaf emergence among species remains consistent (Skvortsov, 1999).

It is recommended that after harvesting, species with attractive catkins should be plunged into water and stored in a 2 to 4 °C (35.6–39.2 °F) cooler; species with colorful stems should be placed immediately in water or may be stored dry at –7 °C (19.4 °F) (Armitage, 1993). The period for marketing can be extended by more than 1 month by forcing the branches early or by cutting them early, holding them in cold storage and then forcing them. Catkins harvested at maturity can be dried to preserve them for months and even years.

Pruning. Grown from cuttings willows will bloom at the beginning of the second season of growth (Food and Agriculture Organization, 1979). Two to 3 years are usually required to produce plants large enough for the first harvest of saleable stems, after which each shrub can produce 10 to 30 stems/year for many years. Cut-stem production for willows requires regular coppicing—cutting to the ground—to promote thicker, straighter, longer single-stemmed branches with more flowers and stimulate further growth if plants have been affected by disease. Optimal coppicing time is during the dormant season, in late winter and early spring which secures a root pool of nutrients for resprouting the following season (Armitage, 1993; Sennerby-Forsse, 1994) and can be done simultaneously with stem harvest. Left unpruned for 2 or more years, branches develop side spurs and are generally less suitable for cut flower production.

Guidance for future selections. The selection of willows for the cut-stem market, can be further extended and underscored by the fact that the genus *Salix* comprises about 450 species worldwide (Argus, 1997). The future search for species can be limited to certain systematic sections. From four subgenera comprising the genus *Salix* (*Salix*, *Longifoliae*, *Vetrix* and *Chamaetia*) the subgenus *Vetrix* should be a focus for future selections for willows exhibiting a showy "pussy willow" effect. The best pussy willows were found in the *Cinerella*, *Daphnella*, *Vimen*, *Subvimen*, *Helix* sections of the subgenus *Vetrix* [the lists of species in those sections appear in Argus (1997) and Skvortsov (1999)]. It is important to use only selected clones for flower production to achieve the consistent performance, because great variation can occur in the structure of the generative organs of wild-collected species.

Conclusions

Our results suggest that many willows described here have production potential over the temperate regions of the United States and Canada. The addition of new Eurasian and North American willows for floral and stem display will increase the market period and choice of ornamental characteristics. Many species can be planted over a wide geographic range, both for increased variety and for longer, more sustained harvest in the floral cut stem market. All the species listed here are recommended for planting in the upper midwestern and northeastern United States and southeastern Canada, cooler areas of Pacific northwestern North America, and for higher elevations in the Appalachians south through eastern Tennessee and western North Carolina. Further research of annual yields, controlled forcing to ensure the predictability of blooming, production cost and consumer value will assist growers in devising successful strategies for ornamental cut-willow production for specific site conditions and regional variation.

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