PROPAGATION OF *CORNUS FLORIDA* FORMA RUBRA BY SEED — THE PROCESS AND POTENTIAL[1]

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Abstract. Plants of *Cornus florida* forma *rubra* are currently propagated by budding or by softwood cuttings. Seed propagation of *rubra* plants would be of interest for economic reasons. Crosses of *rubra* x *rubra* yielded all *rubra* seedlings whereas progenies of *rubra* x a *rubra*/white heterozygote showed 1:1 segregation for pink or red and white-bracted plants. These data are consistent with the hypothesis that the *rubra* characteristic is conditioned by a single recessive gene. Thus, it would be possible to produce pink- and/or red-bracted plants from seed by growing *rubra* plants of diverse origin in an isolated seed block. However, anthocyanin pigmentation of the foliage and bracts of *rubra* seedlings is highly variable; also, undesirable floral "doubles" occur with high frequency in some progenies. The production of pink- and/or red-bracted plants from seed provides the potential for selecting new and superior plants that can be propagated asexually.

Plants of *Cornus florida* forma *rubra* (Weston) Palmer and Steyerm, in cultivation since 1731 (6), have long been prized for the floral contrast they provide in mixed plantings with white-bracted plants typical of the species, *C. florida*. As used in the nursery trade, *rubra* includes both pink- and red-bracted plants. Historically, *rubra* plants have been propagated by budding, a relatively expensive form of propagation. In recent years, some growers (2,3,4,7) have reported success in propagating this plant material more economically from stem cuttings under intermittent mist, but there is still controversy among propagators as to whether or not plants of *C. florida* f. *rubra* propagated from stem cuttings are less winter-hardy the first few years than are plants of the same clones grafted onto the typical white-bracted seedling understock. Some nurserymen, largely for economic reasons, are showing increasing interest in producing pink- and/or red bracted plants of *Cornus florida* from seed. This paper discusses techniques and problems associated with producing such plant material from seed.

INITIATION OF BREEDING PROGRAM

In 1965, bare-root plants of most of the cultivars of *C. florida, C. kousa*, and *C. Nuttallii* available in the trade were assembled in performance trials at the New Jersey Agricultural Experiment Station, Cook College, Rutgers University, as the first step in initiating a breeding program devoted to the devel-

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opment of new and superior cultivars of the flowering dogwoods through intra- and inter-specific hybridization. One of the objectives of this program was, and remains, the development of superior cultivars with pink and/or red bracts. Over the years, nurserymen specializing in *C. florida* have had the opportunity to observe and evaluate millions of white-bracted dogwood seedlings. As a result, numerous excellent cultivars of the species type were available in the trade when the current hybridization work was initiated. In contrast, the cultivars of *C. f.* forma *rubra* were limited in number and traced directly to plants found in the wild or selected from relatively small seedling populations. Therefore, it seemed reasonable to attempt to develop improved cultivars with pink and/or red bracts from more diverse germplasm through intraspecific hybridization.

ORIGIN OF CULTIVARS UTILIZED

Initially, the available cultivars of *C. f.* forma *rubra* included 'Prosser Red' (D48), 'Cherokee Chief' (D7), 'Sweetwater' (D18), 'Spring Song' (D55), 'Welch's Jr. Miss' (D75), and an unnamed clone (D3) obtained from Princeton Nurseries:

1. 'Prosser Red' (dark red bracts) — traces to a plant discovered in a wooded area on the Prosser Estate in Knoxville, Tennessee (8).
2. 'Cherokee Chief' (medium dark red bracts) — traces to an open-pollinated seedling of 'Prosser Red' found by Mr. Bruce Howell in a nursery row on his farm in Sweetwater, Tennessee (8).
3. 'Sweetwater' (red bracts) — a sibling or half-sibling of 'Cherokee Chief,' tracing to the same planting of open-pollinated seed from 'Prosser Red' (8).
4. 'Spring Song' (red bracts) — this cultivar was introduced to the trade by the Wayside Gardens Company, the plants having been produced from propagation wood taken from a tree growing in a large planting of dogwoods on an estate in the East.
5. 'Welch's Jr. Miss' (dark red bracts) — originating in the deep South, this cultivar traces to a plant found by Mr. Clarence Welch, Welch Brothers Nursery, in the wild in Alabama (8).
6. D3 (red bracts) — The clone designated D3 in the pedigree records of our *Cornus* breeding program at Rutgers is produced by Princeton Nurseries, Princeton, New Jersey. This clone traces to a plant found by a farmer in a pasture near Chester, Pa., and was placed into commercial production by a Mr. Achelis who was a Pennsylvania fruit grower (5).

RESULTS AND DISCUSSION

As any dogwood grower who has ever attempted to produce pink- or red-bracted plants of *C. florida* from seed undoubtedly knows, plants of this species are highly self-sterile. However, plants of different cultivars hybridize readily except, of course, in those not too rare instances where plants of the same clone have been introduced to the trade under two or

more names. As indicated by the data shown in Table 1, all plants resulting from crosses of *rubra* x *rubra* exhibit anthocyanin pigmentation in the floral bracts. However, the level of pigmentation in the progenies of the first 3 crosses listed in Table 1 is extremely variable. In the last 2 crosses shown, extensive winter injury to the trees and flower buds resulted in the development of flower heads with two small, distorted bracts, the outer bracts of each flower bud remaining undeveloped. Under such conditions, the pigmentation of the stunted bracts appears to be intensified. The variability in the expression of the pigmentation of the normal bracts in *rubra* seedlings is not unexpected. Being self-sterile, plants of *C. florida* are obligately cross-pollinated in nature and would be expected to be heterozygous for many genes, some of which could modify the expression of a major gene conditioning anthocyanin pigmentation in the plant.

Table 1. Subjective visual ratings of anthocyanin pigmentation of the floral bracts of seedlings resulting from crosses among 5 selected clones of *Cornus florida* forma *rubra*.

	Number and percent of progeny							
		Pigmentation of floral bracts						
Cross	non-fl.	lt. pink	pink	pinkish-red	red	dark red	total	floral doubles*
D3xD7	4 (4.8%)	6 7.2%)	13 (15.7%)	17 (20.5%)	32 (38.6%)	11 (13.2%)	83 (100%)	12 (14.5%)
D3xD18	5 (4.6%)	7 (6.5%)	14 (13.1%)	20 (18.7%)	35 (32.7%)	26 (24.3%)	107 (100%)	7 (6.5%)
D7xD55	1 (1.5%)	1 (1.5%)	8 (11.6%)	12 (17.4%)	35 (50.7%)	12 (17.4%)	69 (100%)	20 (29.0%)
D55xD18					6 (60%)	4 (40%)	10 (100%)	1 (10%)
D75xD7					6 (33.3%)	12 (66.6%)	18+ (100%)	— —
D75xD18	2 (3.1%)		2 (3.1%)	1 (1.6%)	25 (39.1%)	34 (53.1%)	64+ (100%)	— —

* Flower heads exhibit extra bracts (small and undeveloped) and few true flowers.

+ Bract color intensified due to two-bracted condition resulting from winter injury.

Additional information on the mode of inheritance of the *rubra* characteristic was obtained by crossing the unnamed clone (D3), 'Prosser Red' (D48), and 'Spring Song' (D55) with plants of 'Apple Blossom' (D77) (Table 2). Introduced by the Wayside Gardens Company, 'Apple Blossom' traces to a tree on the same estate where 'Spring Song' was selected. The name was chosen as being descriptive of the pigmentation of

the floral bracts of the plants during some seasons. However, the intensity of the anthocyanin pigmentation of the bracts in this cultivar is extremely variable from year to year and was observed to be essentially the same as that observed with seedlings resulting from controlled crosses of *rubra* x white, the bracts being nearly pure white during most years.

Table 2. Subjective visual ratings of anthocyanin pigmentation of the floral bracts of progenies resulting from crosses between three clones of *Cornus florida* forma *rubra* and 'Apple Blossom' (D77).

	Number and percent of progeny *pigmentation of floral bracts*					
Cross	white	white with tinge of pink	pinkish-red	red	dark red	total
D77xD3		10	5		1	16
D77xD55	3	3	2	5	2	15
D48xD77		10	2	6	4	22
all crosses	3	23	9	11	7	53 (100%)
white vs. *rubra*		26 (49.1%)		27 (50.9%)		

The simplest hypothesis regarding the mode of inheritance of the *rubra* characteristic in *C. florida* is that it is conditioned by a single recessive gene. The data in Tables 1 and 2 are consistent with this hypothesis. The 1:1 segregation for *rubra* versus white bract color in the progeny of the 3 crosses involving 'Apple Blossom' (Table 2) is clearly consistent with the hypothesis that plants of this cultivar are heterozygous for a single pair of genes conditioning bract color.

It should be noted that 5 of the 7 crosses listed in Table 1 yielded a substantial number of plants exhibiting flower heads classified as "doubles." Most of the "doubles" were vastly inferior to the flower heads of the white-bracted cultivar known in the trade as 'Flora Plena,' as the majority of the extra bracts were small and distorted and the trait was variably expressed throughout the tree and varied in degree of expression from year to year. Thus, the expressivity of the "doubles" character appears to be markedly influenced developmentally either by internal factors or by environmental factors. The limited data that are available merely allow one to say that this character appears to be related to the gene conditioning the *rubra* characteristic as "doubles" have rarely been observed in seedling populations resulting from crosses between white-bracted plants. Progency of the crosses involving 'Welch's Jr. Miss' (Table 1) were not scored as including "doubles" but the pres-

ence of this trait may have been masked by the severe winter injury which is inflicted annually on flower heads of seedlings from this southern cultivar.

Having established that crosses of selected plants of *C. f.* forma *rubra* yield all *rubra* seedlings, crosses were initiated with select *rubra* seedlings from crosses involving the winter-hardy clone (D3) from Princeton Nurseries. The results of one such cross are presented in Table 3.

Table 3. Subjective visual rating of anthocyanin pigmentation of the floral bracts of seedling *Cornus florida* f. *rubra*.

	Number and percent of progeny							
		Pigmentation of floral bracts						
Cross	non-fl.	lt. pink	pink	pinkish-red	red	dark red	total	floral doubles
D3x (D3xD18)	5 (5.2%)	3 (3.2%)	24 (25.3%)	21 (22.1%)	27 (28.4%)	15 (15.8%)	95 (100%)	1 (1.1%)

The progeny of this cross illustrate further the variability encountered in the expression of the anthocyanin pigmentation of the floral bracts in a seedling population of *rubra* plants. Apparently, one backcross generation had little effect in reducing this variability. One floral "double" was observed among the seedlings.

With reference to the variability in bract color exhibited by the progenies listed in Tables 1, 2, and 3, it should be mentioned that the intensity of the pigmentation of the bracts is usually indicative of the intensity of the anthocyanin pigmentation of the foliage. Furthermore, in the experience of this researcher, the intensity of the expression of the anthocyanin pigmentation in the foliage appears to be inversely related to the vigor of the plant, possibly because the anthocyanin pigmentation may reduce photosynthetic activity in the leaves. At any rate, the point to be made is that any search for a parental combination yielding progeny exhibiting uniformity in the intensity of the bract color should be directed away from the dark red phenotypes. Plants exhibiting intense anthocyanin pigmentation of the foliage do not invariably possess dark red bracts. However, it would probably be difficult to find a parental combination that yields progeny with lightly pigmented foliage and uniformly dark red bracts.

EXPRESSION OF THE *RUBRA* CHARACTERISTIC IN DEVELOPING SEEDLINGS

Based on the findings reported above, it would be relatively simple to produce plants of *C. florida* forma *rubra* from seed

if one were to grow *rubra* plants of diverse origin in an isolated stock block.

Another aspect of the problem is that it would be 5 to 6 years under field conditions in New Jersey before the majority of the plants would flower so that one could assess the level of pigmentation in the bracts. However, *rubra* seedlings can be detected a few days following germination as the underside of the cotyledons develop anthocyanin pigmentation. Also, the expression of anthocyanin pigmentation is quite marked in the first true leaves. Thus, it would be possible to rogue contaminant seedlings very early on the basis of their green cotyledons or at later stages of growth on the basis of their green foliage. Possibly, one could eliminate most of the plants that would ultimately produce light pink bracts by rogueing all seedlings that show only light anthocyanin pigmentation on the underside of the cotyledons or in the first true leaves, but this would be a tedious operation. Unfortunately, one would still have to accept a degree of variability in the intensity of bract pigmentation when the *rubra* seedlings flower as the intensity of pigmentation in the cotyledons or in the foliage is not always directly related to the intensity of pigmentation in the bracts. An obvious approach would be to resort to sib matings of select seedlings or to backcrossing select progeny to a parental cultivar in an attempt to produce a line homozygous for the *rubra* characteristic but exhibiting less variability in the intensity of the anthocyanin pigmentation. Furthermore, the parental combination should yield progeny free of the undesirable floral "doubles." At this point, one should be cautioned to be very alert to the possibility of encountering inbreeding depression. Plants of *C. florida* are highly self-sterile but progeny resulting from self-pollination have been obtained in the work at Rutgers University. Those plants have been abnormal in habit and low in vigor. If this low vigor is, in fact, a result of inbreeding, progeny resulting from sib matings or from backcross matings would be expected to exhibit inbreeding depression to a lesser degree.

When one considers the "dogwood decline" that has been occurring in New Jersey and other areas in the eastern U.S. in recent years, it seems clear that *C. florida* is a species in which the best genetic material is none too good. Superimposed on this is the fact that plants of *C. florida* forma *rubra* are not as vigorous or winter-hardy as the species type (1). Thus, not even low levels of inbreeding depression could be tolerated.

POTENTIAL FOR DEVELOPING SUPERIOR CLONES OF *CORNUS FLORIDA* FORMA *RUBRA*

The production of plants of *Cornus* forma *rubra* from

seed offers the potential of reduced costs of production. However, considering the variability in vigor as well as in bract color that must be tolerated in the end product, should one expect to gain commercially, or economically? This variability probably would be of no consequence in highway plantings. However, from the perspective of the plant breeder, plants of a tree species that might be expected to remain in a residential or business landscape for a period of 25 to 30 years should be the best genetic material that is available. At present, that is not pink- or red-bracted dogwood grown from seed.

The most promising aspect of generating plants of *C. f.* forma *rubra* from seed is the potential for selecting one or more superior plants that can be reproduced asexually. In the breeding program at Rutgers University, this aspect of the work will receive high priority.

LITERATURE CITED

1. Bailey, L.H. 1928, The Standard Cyclopedia of Horticulture. Vol. 1:854. New York, Macmillan.
2. Bauer, Carl. 1977. Producing dogwood by cuttings. *Proc. Inter. Plant Prop. Soc.* 27:238-240.
3. Bauer, Carl. 1978. Propagation of *Cornus florida* cultivars by cuttings. *Proc. Inter. Plant Prop. Soc.* 28:360-363.
4. Clay, Leslie K.C. 1973. Propagation of dogwoods by cuttings. *Proc. Inter. Plant Prop. Soc.* 23:56-58.
5. Flemer, William, III. Princeton Nurseries, Princeton, N.J. Personal communication.
6. Rehder, Alfred. 1954. Manual of Cultivated Trees and Shrubs Hardy in North America. New York, Macmillan.
7. Savella, Leonard. 1980. Propagating pink dogwoods from cuttings. *Proc. Inter. Plant Prop. Soc.* 30:405-407.
8. Shadow, Don. Shadow Nursery, Inc., Winchester, TN. Personal communication.

HARRISON FLINT: You mentioned a cultivar that is not hardy in the north. What was it?

ELWIN ORTON: 'Welch's Jr. Miss.'

DON SHADOW: Have you tried to incorporate the red-bracted form into other forms, such as the dwarf and weeping forms?

ELWIN ORTON: Yes. We have put effort into developing dwarf, red-bracted forms. The weeping form I have never been impressed with and have not tried.

RUTH KVAALEN: Is there a red-bracted *C. nuttallii*?

ELWIN ORTON: I am not aware of any and the people on the West Coast tell me no.

VOICE: Have you considered similar studies with *C. kousa*?

ELWIN ORTON: Yes, we have. However, there are no pink or red forms of *C. kousa*. We did interspecific crosses between *C. florida* and *C. kousa* at the suggestion of Hans Hess with the idea of producing a pink *C. kousa*. We have also incorporated *C. nuttallii*. The major thrust of our work now is interspecific hybridization. I have imported supposedly pink forms of *C. kousa* from Japan but they have all produced only white flowers. I have chased down many claims of pink flowered *C. kousa* dogwoods. Every year I get calls from people who have pink-flowered *C. kousa* and they are right. If you look at them during a 24-48 hour period when the flowers are senescing they will have a pink color. In some cases I have seen the color last for 7 days.

AL FORDHAM: If the flowers abort, you will also get pink bracts.

PROPAGATION OF TRIFOLIATE MAPLES BY SEED

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In the section *Trifoliata* of the genus *Acer* are 4 species: *A. griseum*, *A. mandshuricum*, *A. maximowiczianum* (*A. nikoense*) and *A. triflorum* (10). The species are characterized by short tree stature at maturity and autumn foliage of red, scarlet, or orange. A cinnamon-brown or yellow-brown flaking bark of *A. griseum* and *A. triflorum*, respectively, further enhance the horticultural qualities of these maples, making them excellent ornamentals.

Schizocarps of *A. griseum*, *A. maximowiczianum* and *A. triflorum* have a ligneous pericarp which delays germination for several years (3,6). Two to 5 years can elapse between good fruiting, with most fruits producing few seeds exhibiting double dormancy (6,15). Trifoliate maples are not easily rooted by cuttings but can be grafted; however, they need a rootstock of a similar species. Thus, trifoliate maples are rarely seen in cultivation.

Dormant seeds of *Acer* have germinated following gibberellin or kinetin treatments (12,13). Radicle elongation of *Acer pseudoplatanus* was promoted by kinetin while gibberellin treatment promoted cotyledon unrolling and growth (9). This paper reports results from experiments conducted to deter-