The Dogwood Improvement Program at the University of Tennessee

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INTRODUCTION

Flowering dogwood, *Cornus florida*, comprises about 16% of all woody ornamental plant production in Tennessee. Annual sales of this species accounts for $50 million. Flowering dogwood is an important and widespread component of eastern woodlands. In recent years, two destructive diseases have severely impacted native stands of flowering dogwood, and to a lesser degree have caused problems in nursery and landscape situations. Dogwood anthracnose (*Discula destructiva*) was first observed 20 years ago in Connecticut and has since spread rapidly through native stands in the Appalachian mountains and highlands. In the last 5 years, flowering dogwoods have been under an epiphytotic attack throughout the eastern U.S. by powdery mildew (*Microsphaera pulchra*). While generally not life-threatening in the woods, powdery mildew severely reduces growth of nonsprayed seedlings in nurseries, thus impacting budding operations. The University of Tennessee Institute of Agriculture (UTIA) formed a multidisciplinary team of scientists to research solutions for these disease problems.

Dogwood Anthracnose. This disease was first reported in eastern and western regions of the U. S. about 20 years ago. It was discovered in Tennessee in 1988, and pathologists set up survey plots to track the spread and severity of the disease throughout the southeastern states. Concerned researchers, regulatory personnel, and U.S. Forest Service staff, primarily from southeastern states, convened a series of dogwood Anthracnose Workshops to exchange information, plan research, and track the spread of the disease. *Discula* is sensitive to heat [above 30°C (86°F)] and dry weather — thus it was worst for plants at high elevations, on northern slopes, situated near foggy sites or water, and on shady sites as opposed to trees located in open sites. Thus, the fungus was initially difficult to inoculate in the greenhouse and laboratory. This problem was overcome and progress swiftly mounted on epidemiology, means of dispersion, and control measures. We now know that spores can over winter in active cankers, dead leaves, and berry tissue and that sporulation begins in cool moist weather in mid-spring. Spores can spread via windblown rain and mist as well in the gut and on the skin of a variety of insects. Secondary infections continue as long as weather conditions are favorable.

Definitive verification of disease presence depends on the distinctive appearance of the spores. Dogwoods grown at lower elevations in open nursery fields, as is usually the case, are generally at little risk. Since this is a quarantinable disease, growers must protect their stock with fungicide sprays. Banner MAXX, Daconil 2787, Dithane F, Systhane 2EC or 40WP are labeled and give excellent protection when applied at 10 to 14 day intervals in the spring until hot weather occurs consistently. A more economical solution would be to use resistant cultivars. At a

dogwood anthracnose workshop, Keith Langdon of the National Park Service reported finding two trees that survived the epiphytotic which had killed nearly all the flowering dogwood at the top of Catoctin Mountain in Maryland. In a subsequent search by Mark Windham (UTIA) five Catoctin Mountain survivors were discovered and he obtained permission to take cuttings. Cuttings were harvested in early July 1991 and propagated under intermittent mist, using Hormodin #2 and peat and perlite medium. Rooted plants were placed under a long-day photoperiod, fertilized with 200 ppm N Peters 20N-10P-20K to induce a growth flush, and overwintered in a minimum heat greenhouse. Plants were transplanted into larger containers and then challenged for dogwood anthracnose resistance at Ozone, Tennessee in 1992 and in a double blind test at Bent Creek Forest near Asheville, North Carolina in 1996. Most of the rescued clones showed some resistance when compared to the controls, but only one clone exhibited strong resistance. When that clone bloomed, we were pleased that bract size, quantity, and quality was as good as many named cultivars. We continued to root cuttings whenever cutting wood was available. Two of the original cuttings were planted in our field nursery and are now 2.4 m (8 ft) tall with a diameter of 2.1 m (7 ft), and a trunk caliper exceeding 6 cm (2.5 inches). Despite removal of wood for cuttings and budsticks, a normal growth habit and horizontal branching is developing. Leaf color is apple green with lighter venation and no hint of anthocyanin reddening. Leaf size is strikingly large (25% longer and wider than 'Cherokee Brave'). DNA fingerprinting was conducted and five distinctive markers were identified. Principle Coordinate Analyses showed that our resistant clone was located outside the cluster of five other dogwood cultivars commonly used in the industry.

Release of 'Appalachian Spring'. The UTIA plant release committee has approved the name 'Appalachian Spring' and the release has been published (Windham et al., 1998). Since the original tree was found in the wild, it cannot be patented. However, the cultivar is being closely controlled. The word 'Appalachian' is being considered as a trademark name for the series of dogwoods that we intend to release. Buildup of foundation stock and marketing is controlled by the Tennessee Crop Improvement Association (TCIA), Tennessee Foundation Seed, Inc. (TFS), and Tennessee Advanced Genetics (TAG) — all located at 2640-C Nolensville Road, Nashville, TN [615.242.0467, FAX 615.248.3461]. Foundation stock is being multiplied by a few growers in Franklin County, Tennessee. We appear to be 1 or 2 years away from the next step, which is the formation of a marketing group by TAG.

Powdery Mildew. Powdery mildew on flowering dogwood is caused by two organisms, *Microsphaera pulchra* and *Phyllactinia guttata*. The former appears to be the most prevalent problem today. This disease was never significant until 5 years ago when an epiphytotic suddenly exploded throughout the eastern U.S. While having only moderate impact in forest sites, powdery mildew causes major growth reduction of flowering dogwood in nurseries, especially on seedlings, young plants, and variegated cultivars. Understock fails to sufficiently develop to meet growth standards required for budding. Mildew appears later in the season than dogwood anthracnose, but can progress rapidly unless fungicides are applied. The same fungicides that are effective for dogwood anthracnose prevent powdery mildew with the exception of Daconil 2787. In addition, growers can apply Rubigan

AS, Bayleton 25WP, Cleary's 3336F, or Zyban 75WP. Cover sprays should be applied every 7 to 10 days when two conditions are met: (1) night temperatures do not drop below 21°C (70°F) and (2) nighttime relative humidity is 85% or more. Best control and minimum phytotoxicity is obtained when fungicides are rotated in a spray program.

Powdery-Mildew-Resistant Plants. We screened 22,000 dogwood seedlings in nursery fields in 1994 and 1995. Eighty seedlings were flagged as being free of signs and symptoms of powdery mildew. In the fall, these were dug and taken to the UTIA research nursery, where they were containerized and overwintered. Seedlings were again challenged for disease resistance in a shaded greenhouse, which was maintained at high humidity, and included an abundance of inoculum from potted dogwood trees with mildew. While none of the seedlings were immune, 20 remained almost free of mildew under the artificially high disease pressure. In contrast, the moderately resistant 'Cherokee Brave' cultivar developed mildew. Resistant seedlings were propagated by rooted cuttings. Six trees bloomed in Spring 1998. Two consumer preference surveys have been conducted and we currently plan to name and release the three best clones. Since these trees were found in cultivation, they are patentable and UTIA is proceeding with plant patent applications for this group of the Appalachian™ series of dogwoods. We are currently rescuing and testing additional flowering dogwoods that appear to be disease resistant in nursery fields. This is not as easy as in the beginning because almost all nurseries are using fungicides and we can no longer simply walk rows and pick out good plants.

Breeding Efforts. Our breeding work has been only with *C. florida*. Initial efforts began in 1993, mainly via manual emasculation and pollination on containerized trees of a number of cultivars. Flowering dogwood is an obligate out-crosser and will not set seed when self-pollinated. To verify the hypothesis that insects naturally played the major role in dogwood pollination, five trees each of 'Cloud Nine' and 'Cherokee Brave' were placed in a large double screened cage which excluded all insects. Since the trees bloomed normally but no berries were set, we conclude insect pollinators are necessary. We attempted to trick honeybees into pollinating dogwood flowers, something they do not ordinarily do. We built screened cages around our two largest 'Appalachian Spring' trees, synchronized the bloom of containerized 'Cherokee Brave', and introduced them into the cages along with nuclear colonies of honeybees. About twice a day during warm weather, a droplet of sugar solution containing queen mandibular pheromone (9-oxydecenoic acid) was placed on the base of a bract of each inflorescence with open flowers, being careful not to get the material on the true flowers or on leaves. Significant bee feeding was induced and we observed bees moving between trees. By the time bracts fell, berry set had occurred and we removed the bees and opened the cages. As berries ripened in the fall, they were harvested, labeled, cleaned, and stratified. Seedlings were germinated in the greenhouse and when three pair of leaves had formed, one developing leaf was harvested for DNA analysis. Profiles confirm hybrid origin, thus reducing the need to rely on morphological characteristics. Hybrid seedlings are grown on, cuttings propagated to build up a small stock of a clone, and the clones will be challenged for resistance to both dogwood anthracnose and powdery mildew. So far we have several hundred seeds and plants progressing through this process. We have also raised open pollinated seedlings from the six powdery-mildew-resistant clones that have

bloomed, and hundreds of open-pollinated seedlings of 'Cherokee Brave'. Of these, few have shown significant resistance to powdery mildew, so inheritance is not simple, and it may not be the same in all resistant trees. We think more than one gene is involved and that recombination of resistance genes in the F_2 generation may be needed. If this hypothesis proves correct, it suggests we are six or more years away from producing F_2 seed, plus additional time for growing and testing hybrid seedlings in the hope of finding one or more flowering dogwood trees resistant to both diseases.

Chinese Dogwood Selections. About 10 years ago, Polly Hill of Vineyard Haven, Massachusetts, reported the occurrence of dogwood anthracnose on some *C. kousa* selections. We requested seed from diseased trees and also disease-free trees. She graciously complied, and in 1990, we cleaned, stratified, and germinated the seed. Each seedling was labeled with a code that identified the parent tree. We challenged these seedlings for dogwood anthracnose resistance in the Great Smoky Mountains National Park and found no correlation between disease ratings and the parent, indicating that inheritance is not simple. Five hundred of the best seedlings were planted in a non-irrigated field at the UT Arboretum in Oak Ridge. The largest trees bloomed in 1998. We flagged five trees that had prolific bloom and good bract size and shape. A drought occurred later that year and we flagged trees that were free of leaf scorch and leaf curl, and had dark green color and horizontal presentation of foliage. In late Summer 1999, east Tennessee experienced the worst drought in 100 years. We re-examined for drought tolerance and flagged 10 trees, pleased that most were repeats from the previous year. These trees were equal or better in quality of foliage during the drought than 'Blue Shadow', 'Temple Jewel', and 'Trinity Star', which performed best during the drought in our replicated cultivar trial. Next year we will propagate cuttings from our selections. We plan to conduct replicated trials in a deep-South location, as well as at a northern site to test for cold hardiness. Eventually, we hope to name and release one or more cultivars of heat- and drought-tolerant Chinese dogwood.

LITERATURE CITED

Windham, M.T., E.T. Graham, W.T. Witte, J.L.Knighten, and **R.N. Trigiano.** 1998. *Cornus florida* 'Appalachian Spring': A white flowering dogwood resistant to dogwood anthracnose. HortScience 33(7):1265-1267.