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Horticulture Is. . . .

biological survival
scientific research
urban development
human aesthetics

The Twenty-seventh Congress of the American Horticultural Society

September 6-10, 1972

Olympic Hotel, Seattle, Washington

Each day of the 1972 Congress program presents a broad range of interests. Morning lectures will relate to the Congress theme followed by lecture tours covering native plant development, forest management, the University of Washington Arboretum, nurseries, urban planting, public and private gardens, and more. No time conflict occurs with lectures and tours; preregister for both.

Featured will be a horticultural exhibit at the Pacific Science Center which will be representative of more than 200 plant families, 1,000 genera, and 8,000 ornamental species showing the extensive range of the plant kingdom which can be grown in the Pacific Northwest. Mrs. Horace Raphael, Horticultural Steering Committee member, is chairman of the notable Bonsai exhibit to be displayed at the Seattle Art Museum Pavilion.

Six Post-congress Tours are arranged; Congress registrants may choose from tours visiting alpine meadows, a flight through the San Juan Islands, a trip to the Mt. Rainier rain forest or longer trips to the Olympic Peninsula or to Victoria and Vancouver, B. C. A travel agent has been authorized to offer tours to Japan, to Hawaii, to Alaska and along the Pacific Coast.

Speakers during various sessions of the Congress include: Dr. Henry T. Skinner, Director of the United States National Arboretum; Dr. René Dubos, Professor Emeritus of Rockefeller University; Dr. James S. Bethel, Dean of the College of Forest Resources, University of Washington; Dr. Dixy Lee Ray, Director of the Pacific Science Center; Mr. H. G. Hillier of Hillier & Sons Nurseries, and Dr. Kenneth V. Thimann, Provost of Crown College, University of California.

Several notable A. H. S. members will participate in portions of the program; the film festival will be held during the Friday Morning session.

For information on The Twenty-seventh Congress of the American Horticultural Society write to: Mr. O. Keister Evans, Executive Director, The American Horticultural Society, 901 North Washington Street, Alexandria, Virginia 22314, or to Mrs. Pendleton Miller, Chairman, A. H. S. 1972 Annual Congress, The Highlands, Seattle, Washington 98177

an editorial . . . .

All Those In Favor Of Plastic Bushes. . . .

Newspapers, magazines and television carried, in late winter months this year, information on the installation of plastic "plants" on a Los Angeles County boulevard. Most of the coverage was negative.

The editors of *Nursery Business* magazine, in their March/April issue, took a stand for the use of plastic "plants" in public landscaping. They decry public condemnation of artificial landscape materials and defend the users of it. They say that people have been carried away by "emotional feelings baited by the 'do-gooder' ecologists." They call these travesties of trees and shrubs "permanent type shrubbery and plant materials" (without quotes to identify the stuff as synthetic) and state that, in a difficult site such as a freeway medial strip, its use is justified. These plant industry editors follow the line of reasoning prevalent among today's youth (e.g., if rape is happening, it must be acceptable) when they say:

> *"It is a matter of record that many sellers and distributors of 'green goods' are also selling permanent type shrubbery (ed. note that real plants are referred to in quotes while synthetics are not bracketed) for these special and unusual situations. Since most landscape planning is yet, in today's world, a matter of 'cosmetic' treatment, then we are inclined to say that it is much, much better to have these roadway areas, drive-ins, filling stations, motels, and the high service, low maintenance type public service areas visually improved with proper assortments of permanent type landscape plants than to allow them to stand as blighted areas to distress anyone coming in contact with them. It would be just as illogical to insist that fencing, walkways, benches, even buildings themselves, are ecologically unacceptable and therefore should not become a part of the landscape."*

How's that for an exposition of complete ignorance of principles of landscape design for public areas? And quite indefensible, in the case at hand, with the Los Angeles County Arboretum immediately available, and presently carrying out research and tests on plant materials for special and unusual situations.

While University departments of horticulture research plant hardiness and resistance to stringent environments, while private and governmental agencies continue to research modifications of soils for plants growing in limiting sites, while plants are being bred by individuals, companies and public agencies to grow successfully in difficult areas, there is absolutely no justification for cluttering the landscape with synthetic objects.

Apparently the editors of *Nursery Business* never have seen plastic objects after a few weeks' exposure to the sun's bleaching rays. Or when the plastic is smudged with sludge kicked up from a filthy, oily roadway. A tough, living plant soon produces new, green shoots to cover up the blackened foliage; very little new growth can be anticipated from plastic "plants." The use of non-biodegradable objects in the landscape defeats the whole goal of beautification. It adds to pollution. The only difference between a plastic carton and a plastic bush is size, so far as environmental pollution is concerned.

There is quite another aspect. The nursery industry is endangered by a pro-plastic philosophy. Look at the nation's florist shops; once these were filled with fresh flowers and plants. Today much of the retail florist business is cheap crockery and artificial "flowers". Not only has the wholesale florists' industry suffered, but the quality of life in homes adorned with such frippery is degraded. The growers of quality nursery stock would do well to object loudly and at length when a publication that claims to speak for the nursery industry invites the plastic camel into the marketing tent.

One bright spot emerges from the Los Angeles County decision to "beautify" its boulevard with a reported $75,000.00 worth of plastic brush. While plant lovers across the nation were saddened, angered or disgusted, Los Angeles citizens reacted.

The Cleveland Press, and other papers, reported that, after looking at the "permanent type shrubbery" (which the editors of *Nursery Business* found so suitable for the boulevard medial strip) the citizens of Los Angeles County tore out the stuff and destroyed it! It is to be hoped that, the next time the editors of *Nursery Business* write up a glowing report of landscaping with plastic objects, they point out that "permanent type shrubbery" is apt to be remarkably impermanent because if solar rays and traffic splash do not destroy it, offended people will.

And, a note for citizens faced with public landscaping projects:

A plant of some sort will grow in almost every situation. Presently, A.H.S. is compiling a list of species that succeed in horticulturally awkward sites such as median strips, in raised planters or sidewalk "pockets" in downtown areas, or in the compacted soil of public parks and playgrounds. This information is coming to our computor center (The A.H.S. Plant Records Center) from all over the country. If you need a recommendation for a plant for a specific site, try us. If we do not yet have the information available, we are able to refer you to a local information source such as a botanical garden or arboretum which will supply the facts you need. Good horticulture is not dead; it just is *terra incognita* to editors of at least one trade journal.— **J.P.B.**

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JOHN PHILIP BAUMGARDT, *Editor*

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IN THIS ISSUE

OUR COVER PHOTO—*Passiflora incarnata* is native from Zone VI southward, from the Atlantic coast west through Oklahoma and east Texas. Usually with flowers lavender, banded white, this is the white form. Captain John Smith reported that Indians in Virginia cultivated the plant for its fruits which are called maypops. Once common on roadside fences, the plant now is rare or extinct over much of its range due to weed control spraying. This photo was taken in 1969 in Barry County, Missouri, where passion vines occurred intermittently along Highways 76 and 86; today none remain.

Shailer's Provence, a R. centifolia hybrid, growing to 8 ft. and with lilac-pink anemone-like blossoms.

Searching for Old Roses

George D. Greene and Walter H. Lewis*

Autumn Damask flowers continuously in the St. Louis area and is enjoyed as much now as it was by the ancient Greeks and Romans.

*Curator of Old Roses and Senior Botanist, respectively, Missouri Botanical Garden, St. Louis. Dr. Lewis is also Professor of Biology, Washington University (St. Louis).

With the current feeling that the environment as we once remembered it is quickly passing away, more of us are becoming increasingly nostalgic about early memories which we cherished the most. Perhaps this and our greater leisure time and affluence are responsible for the recent fascination in saving the many old horticultural varieties and cultivars of our childhood and forefathers still found in now abandoned homesteads. From daffodils to roses, these treasures are quickly disappearing from fence rows, farms, cemeteries, old gardens and private collections. Even nurseries selling them are few and their listings grow shorter each year. Many are lost forever and many more are destined for extinction as the bulldozer adds to its hungry quest for new ground.

But what an engrossing hobby for those interested in the outdoors, in collecting, in traveling, and in historical detective work. Who could resist being a plant archeologist? Think of traveling through the past to our earliest western civilization or to the arrival of our forefathers from Europe pinpointed by the plant varieties brought with them. Such research allows us to trace the development of newly produced varieties, to know the historical details of plants, and to preserve the genotypes for future breeding as might be required for changing fashions, for new environments, and for resistance to disease. Clearly a loss of such varieties must be considered a loss to civilization.

To stem this tide of botanical destruction, the Missouri Botanical Garden has a small project now underway to preserve old horticultural roses. As both the "gateway to the west" and a great river port, St. Louis and the upper reaches of the Missouri River had a unique historical position in the center of the continent and as such numerous plants were brought from the East and from Europe. In our outlying areas we are finding interesting old rose cultivars, most of them unlisted for sale anywhere. With their less familiar purple and lilac colored petals having striped, flaked and mottled forms, they are not the sophisticated hybrids of today, but they are of the great Dutch Masters where we are able to recapture the beauty, charm, and fragrance known to them. A few examples from our collection will illustrate the joy of finding antique plants, rare or common.

Who could ignore the singular beauty of the old French roses such as *Rosa centifolia*, the Provence or Cabbage roses, found commonly throughout eastern North America in the form of Shailer's Provence. The anemone-like blossoms are lilac-pink in color; in two years the shrub reaches 8 feet, flowering prolifically. The cultivar is still available from one nursery in this country, yet a search along fence rows and in old gardens to find one's own is of greater personal triumph.

Still another find is the beautiful Autumn Damask or Rose des Quartre Saisons, an ancient variation of the typical *Rosa damascena*, which flowers continuously in the St. Louis area and is a joy to any garden today. Known to Cleopatra and to the ancient Greeks and Romans, its many forms and mutants must be preserved by avid collectors and gardeners for posterity.

More of a mystery is the beautiful 'Klusmeyer', probably of *Rosa chinensis* parentage, but otherwise unknown. It flowers profusely in St. Louis; the petals are lighter pink on the inside and they turn over at the top to form a "pouting lip."

These are but a few examples of the intriguing hobby of plant hunting whether for horticultural or native plants. The non-professional can in this way play a great role in aiding the plant scientist to preserve our heritage. For the old roses, start with two fine texts, *History of the Rose* (R. E. Shepherd, Macmillan Co., New York, 1954) and *The Old Shrub Roses* (G. T. Thomas, Phoenix House Ltd., London, 1955), and with these in hand, explore the countryside for rich returns.

The unknown 'Klusmeyer', a striking rose of China parentage found in a St. Louis garden. Note the 5 ft. shrub with over 100 blooms, the cluster of flowers with fluorescent petals, and the single full flower.

Fig. 1. With extreme age the trunk of Cudrania tricuspidata *becomes deeply furrowed. Note spininess of the basal shoots. (Photograph by Frank N. Meyer, Ya Tze Ko Village, Sianfu, Shensi, China, January 20, 1914.)*

Introduction of Cudrang or Silkworm Thorn into the United States

*Harold F. Winters**

A multitude of foreign plant species have been introduced into the United States that never have become established crops. The reasons for failure are greatly varied. Some introductions such as species of *Cudrania* from Asia could scarcely be considered crop plants in their countries of origin. One species, *C. tricuspidata* (Carr.) Bur., may become a minor dooryard fruit in the United States because of the personal interest of Dr. George M. Darrow and a few other fruit enthusiasts.

The genetic name *Cudrania*, established in 1847 by Trecul, was derived from its Malayan name "Cudrang." If this does not suit the plant as a common name in America one could resort to "Silkworm Thorn." This common English name indicates the principal use made of the tree in China and that it is thorny (W. J. Bean. Trees and Shrubs Hardy in the British Isles, 4th Ed. 1925). This name also is used in the Royal Horticultural Society's Dictionary of Gardening. 1956. I prefer "Silkworm Thorn" because of its meaning and because it already is commonly used. My second choice would be "Cudrang" but this name could apply to the entire genus. Other possibilities are: Chaam Shue, Che, Tcho Che Shu, Tcho Sang and Tsa as reported by plant collectors. They are transliterations from the Chinese and one can never be sure of the accuracy or meaning of such words.

The Department of Agriculture cannot claim to have introduced the very first *Cudrania tricuspidata* brought into this country from China. This credit belongs to the Arnold Arboretum and to E. H. (Chinese) Wilson who returned from China in April, 1909, with 1,473 kinds of living plants and cuttings and 2,262 packets of seeds. The complete distribution history of the first *Cudrania* imported by the Arnold Arboretum is not available. However, the Office of Foreign Seed and Plant Introduction secured seventy-two seeds from a tree grown by P. J. Berckman's Nursery, Augusta, Georgia, (Plant Introduction No. 34493)** on November 11, 1912. Shipments of seeds and plants from the same source in 1916 and 1917 were recorded as P.I. Numbers 44241, 45194 and 45448. Mr. Berckman's tree was described as a compact, somewhat spiny bush, with light green leaves varying from three-lobed to egg-shaped in outline. It was easily propagated by suckers. The twelve-foot tree produced one and one-half bushels of fruit between the middle of August and November.

The first introduction direct from China by the Department of Agriculture was P.I. 35258, collected at Laoling, Shantung, on March 30, 1913, by Agricultural Explorer Frank N. Meyer. The shipment consisted of sixteen rooted plants and was accompanied by the following description: "A wild shrub, sometimes growing into a small tree, found in dry places. Called by the Chinese "Tcho Sang," which means wild mulberry; the leaves are used for feeding silkworms in times of scarcity of mulberry leaves. This plant makes a similar impression as the osage-orange but is of much smaller dimensions. Can be utilized in the drier parts of the United States as a hedge plant around gardens, as a fence material on farms, while it also can be employed for bank-binding purposes in the milder, semi-arid sections. This shrub is very thorny and can serve therefore very well for hedge purposes."

Frank N. Meyer, who explored China for the Department of Agricul-

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***The records of plant introductions processed by the U.S. Department of Agriculture since February 1898 are published chronologically and numerically as* Plant Exploration and Introduction Inventories. *They are to be found in Experiment Station libraries throughout the country.*

ture from 1905 to 1918, photographed the lower trunk (Fig. 1) of a very old tree of this genus at the Village of Ya Tze Ko, south of Sianfu, Shensi, China. His notes read as follows: "The peculiar looking trunk of a Chinese osage-orange called "Tcho Che Shu." The leaves are occasionally used for feeding silkworms. Locally the small, red fruits were considered to be unwholesome."

The record for Plant Introduction No. 44241 contained additional information about its economic value in China: "The silk produced by silkworms fed on these leaves is employed in making lute strings, which give clearer tones than those made from ordinary silk. The tree is said to afford a reddish-yellow dye called "ehe" yellow, used in dying the imperial garments (Gardener's Chronicle 24: 410. 1885."

On October 16, 1926, seeds of *C. tricuspidata* were collected by Floyd A. McClure (P.I. 71304) while enroute from Shuching to Chungmuihoh, Anhwei Province. He recorded the name as "Chaam Shue."

Two additional collections of seed (P.I. 114813 and 129217) were obtained from Szechwan Province and presented to the United States Department of Agriculture by correspondents in China in 1936 and 1938, the latter from Mt. Omei at 1,800 m. elevation. With these introductions came the additional information that the extremely hard wood of the tree is used for tools.

P.I. 79547 was obtained as scions from a seedling selection of *Cudrania* grown by Mr. John Deverger of Crescent, Georgia. The propagations were root-grafted on the related osage-orange. The description accompanying the distribution stated: "The fruits when ripe bear a rough resemblance in appearance to red raspberries, but are mostly of larger sizes—up to an inch or so in diameter. When well ripened, in early or mid-November, they are fairly sweet and of mild agreeable flavor different from any other fruit; they may be eaten fresh or cooked and are said to be suitable for jelly making. Birds are very fond of them, as are also opossums and foxes. The species grow to twelve feet or more high but the grafted trees begin to bear when smaller. The pistillate and staminate flowers are borne on different plants. The tree is thorny and may be used as a hedge plant in the South."

Fig. 2. Fruiting branches of Cudrania tricuspidata.

The stout spiny branches, leaves and fruits of *C. tricuspidata* are shown in Figure 2. In this photograph the leaves appear to be more luxuriant than is common, but this would vary with conditions under which the tree was grown. Juvenile foliage usually exhibits more or less lobing of the apical one-third of each leaf. The fruits in Figure 3 are approximately natural size. Those at the lower left have been cut to show the translucent reddish-purple pulp and seeds.

Since repeated introductions have been made without its "catching on" as a crop it is doubtful that *C. tricuspi-*

data has attributes that would ever lead to its development as a major fruit. However, the experience of the Department of Agriculture and Dr. G. M. Darrow indicates some potential for selection and breeding.

Evidence that the genus *Cudrania* also may be useful in hybridization is given by Andre (Revue Horticole, 1905, pp. 362-63). Beginning in 1896, Andre arranged to have a thornless female plant of osage-orange he designated as *Maclura aurantiaca inermis* (*M. pomifera* (Rof.) Schneid.) pollinated with pollen from a male plant of *C. triloba* Hance. (Revue Horticole, 1896, pp. 33, 205). Six seedlings were grown which he named *Macludrania hybrida*. Evidence for hybridity was based on unisexuality of the parents and on vegetative characters since the seedlings had not flowered at the time of Andre's report. In vegetative characters the progeny was said to resemble the *Cudrania* (pollen) parent much more closely than the *Maclura* or female parent.

Fig. 3. *Fruits of* Cudrania tricuspidata, *natural size.*

Two plants of the purported hybrid were imported from the nursery of H. A. Hesse, Weener (Ems), Germany, in April, 1960 (P.I. 265265). One specimen was planted at the National Arboretum; Washington, D.C., the other at Longwood Gardens, Kennett Square, Pennsylvania. The former is now fifteen to eighteen feet tall. The plant at Longwood is about as tall but not thrifty. It has not flowered.

A related species, *C. javanensis* Trecul, has been introduced repeatedly from Formosa, Hong Kong, India, Java and New South Wales but to my knowledge none survives in the United States. A plant of P.I. 190372 survived for several years at the U.S. Plant Introduction Station, Miami, Florida before succumbing. In English this plant is called "Cocklespur," "Kwakwatsugayu" in Japanese. It is an evergreen, thorny trailing shrub. The staminate and pistillate flowers are borne on separate plants. The fruit is said to be irregular in shape. Some sources give the color as greenish, others golden-yellow or reddish yellow. Maturing in the winter, the one- to three-inch sweet fruits are eaten fresh or preserved in sugar. One source (P.I. 36986) mentioned the sweet, rather insipid tasting fruit, "quite as good a fruit as many others which are eaten." Still another (P.I. 37015) "The fruit of *C. javanensis* is found edible in Japan (i.e. Formosa) but not eaten with a relish." No doubt it could be reintroduced if someone wishes to undertake a hybridization program. Originating as it does from the areas mentioned above, it would be cold hardy only in the extreme south.

Considering the reported merits of the fruits of *Cudrania* species, therefore, it is doubtful that even the best of them ever will be outstanding fruit crops in the United States. Since the fruits ripen into mid-November, *C. tricuspidata* probably should be tried more extensively as wildlife foods.

'Baron' Kentucky bluegrass cluster of tillers and rhizomes. New cultivars are selected for or bred to standards of low growth (reduced sheath length), disease resistance, density, good rhizoming ability, etc.

TURFGRASS CULTIVARS

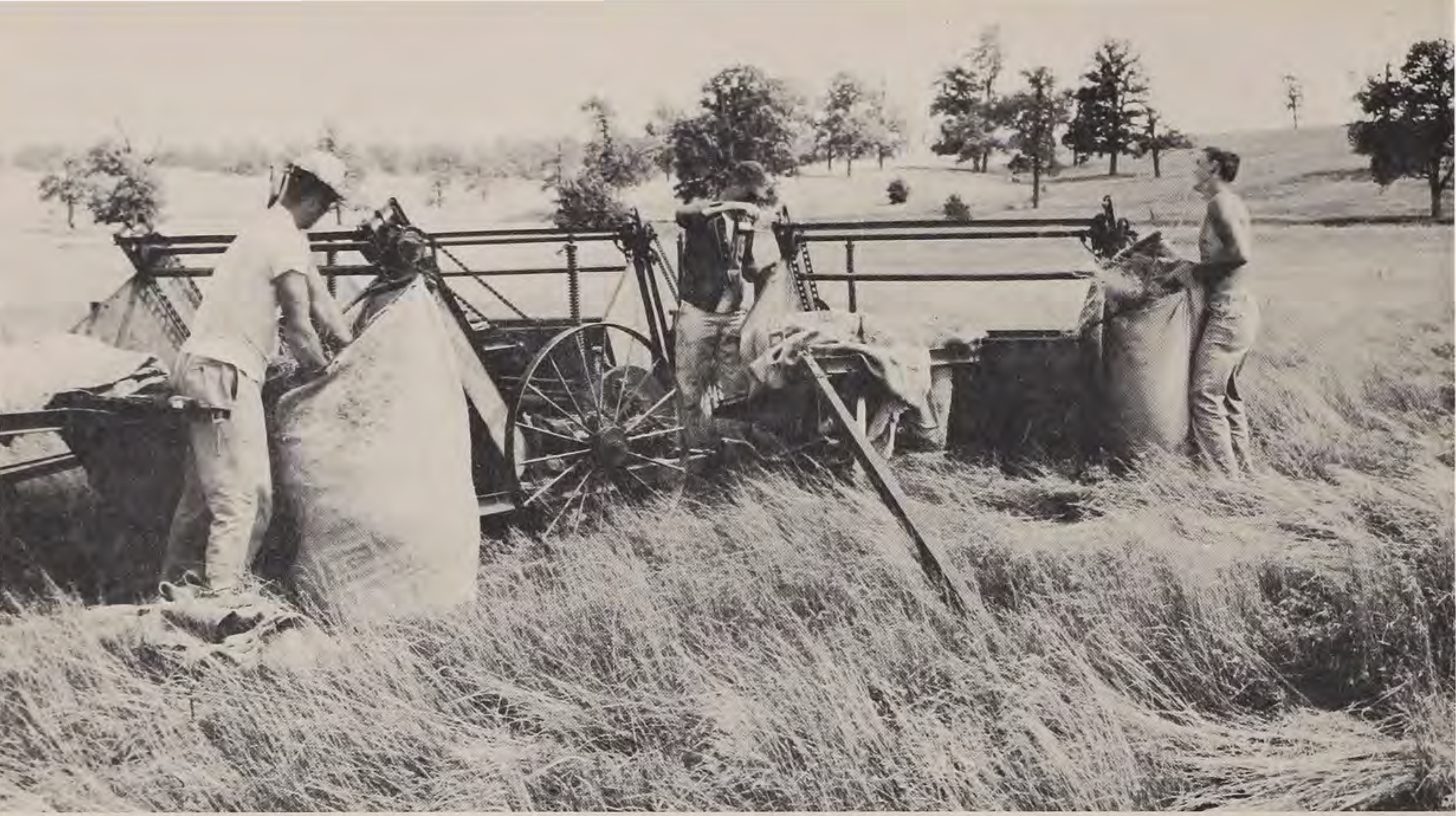
What Constitutes a Modern Lawngrass "Variety"

Robert W. Schery, Director
The Lawn Institute

Gardeners familiar with woody plants (most of which are propagated clonally) and garden annuals (the seed for which is generally a "pure line" or a controlled F_1 hybrid) may be confused by the diversity of genetic forms turfgrass cultivars or "varieties" assume. The cultivars are given unlatinized popular names the same as other horticultural varieties—e.g. 'Highland,' 'Fylking,' 'Penncross,' and others. The specific name, of course, is latinized, as are any botanical subspecific epithets—e.g. *Festuca rubra var. commutata,* Chewing's fescue. But the genetic basis for the cultivars and their modes of propagation vary widely. The range extends from merely adventive (natural) populations molded physiologically by the environment (viz. 'Arboretum' Kentucky bluegrass) to highly sophisticated intraspecific hybridizations (and less frequently interspecific ones, which have not proved overly useful) such as have been conducted by Dr. Reed Funk at Rutgers University.

A cultivar once perfected may be maintained by any of a number of techniques that include clonal propagation (notable with golf green bentgrasses and the finer bermudagrass hybrids), seed maintained essentially as a "pure line" by rogueing of off-types to a standard, and random crossing from proscribed parental lines (three clonally maintained lines in 'Penncross' creeping bentgrass, sixteen "pure line" parent stocks in the multiline 'Manhattan' perennial ryegrass, over a dozen mostly apomictic bluegrass lines in 'Park' Kentucky bluegrass). Maintaining reasonable genetic uniformity in crop after crop of polycross seed harvests requires frequent fresh planting into fields free of the species, lest one of the parental lines become dominant and overshadow others. In the case of 'Penncross' creeping bentgrass, growers in the association have agreed that for certification a seed field will be in production for three years only.

It is impossible to generalize as to which of these procedures is most satisfactory for yielding good turfgrass cultivars. Keep in mind that more so than with most garden plants, turfgrasses are called upon to endure a great diversity of habitat,



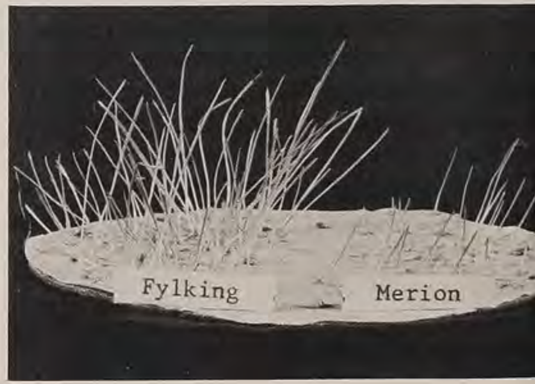
TOP: Adventive natural bluegrass field in Kentucky. The machines have combed "green" seed from ripe panicles, which is being sacked up for taking to the curing yard. All biotypes in the field are harvested and mixed, giving a broad genetic base to the seed stock (typical of 'Arboretum' and 'Kenblue' cultivars).

LEFT: Dr. Joseph Duich inspects a bluegrass turf sample from one of the Pennsylvania State University plots. Extensive testing for disease resistance helped clear the way for the introduction of disease-resistant 'Pennstar' Kentucky bluegrass, bred from uncertain sources long ago imported from Northern Europe.

RIGHT: Drs. Skogley and Griffiths checking spaced plantings of 'Kingstown' velvet bentgrass for trueness-to-type at University of Rhode Island. The inbred line will be source of breeders' seed used for commercial increase in Oregon.

LOWER LEFT: 'Jamestown', an outstanding, low, dark-green chewings fescue adventive on an abandoned golf green at Beavertail Point, R.I. Many fine turf cultivars originate from clones noted by chance to possess outstanding characteristics.

LOWER RIGHT: Subtle differences sometimes distinguish cultivars. 'Fylking', of Swedish origin, has somewhat larger and quicker-germinating seed than 'Merion' Kentucky bluegrass. Merion was noted as an outstanding clone near Philadelphia. 'Fylking' characteristics are more common to European bluegrass than to American.



growing conditions, and methods of maintenance (or lack of it). For general lawn usage heterogeneity (as exemplified by the mixing of cultivars or the use of heterozygous material) has better satisfied needs than has homozygosity and a narrow genetic base that typifies most garden and crop cultivars. With durability of more concern in the lawn than exact morphological homogeneity, it is no wonder that turfgrass breeding programs have been somewhat slower to develop pedigreed grass lines than has been the case with garden plants grown for flower and fruit. Moreover, some of the most important turfgrass species—notably Kentucky bluegrass—are so complicated genetically that established crop breeding techniques accomplish little.

On the whole cultivars of southern turfgrasses—those adapted to warm weather and planted from the border states southward—are most "conventional". Where planted by seed a general population may be used that is not characterized by cultivar definition (e.g. common bermuda or centipede; with bahiagrass a few standard cultivars are used with little attempt to refine the bloodlines). Ready sexual crossing and recombination keeps bermudagrass selections from coming true-to-type from seed, and the finer cultivars (many of them developed by interspecific crossing), must be maintained by clonal separations. This is relatively simple with an aggressive, fast-growing species such as bermuda, where stolons can be scattered much as is seed for making new starts.

Very much the same system is used with zoysia. Local selections or ecotypes ('Emerald' is a man-made hybrid, however) are maintained by clonal planting of sprigs or plugs. So far St. Augustine grass, the sole native species much utilized for turf, has not proved economically amenable to propagation by seed (little is set), and the relatively few selections which have been made and given cognizance as cultivars are, like the common grass, propagated vegetatively. Even with centipede, of which seed is available (although of very small size and quite expensive), vegetative propagation rather than seeding is usual.

Although turfgrass breeding programs are gaining impetus in the South, on the whole there has been rather little isolation and accumulation of breeding stock. The screening of large progeny populations from the crossing of common bermudagrass with African bermudagrass has been the most rewarding source of distinctive, fine turf cultivars (most of them, incidentally, sterile triploids).

Turning to northern turfgrasses, the situation becomes more complicated. This is particularly true with Kentucky bluegrass, a polyploid-aneuploid with an apparent base chromosome number of 7 and with variable chromosome counts (often variable within the same cultivar) even exceeding 150. Natural interspecific crosses and introgression are probably involved, and *Poa trivialis* may have played a part. So great is the potentiality for genetic variation in "wild" adventive stands of Kentucky bluegrass in North America, that early plant breeders believed it rather pointless to attempt hybridization within the species. Dr. Funk has since, of course, shown the advantages of utilizing select genomes. But it is true that in the long course of evolution from a putative diploid perhaps in southeastern Europe, to the widely naturalized bluegrass found in all temperate climates today, that nature has played upon the tremendous variability within the species to create untold biotypes and ecotypes. The main source for bluegrass cultivars has been simple selection of "strains" (usually a clone) showing outstanding features when kept as mowed turf. 'Merion,' one of the first and perhaps the most outstanding of such discoveries, was simply noted growing upon the apron of a green at the Merion golf course near Philadelphia. Most of the many cultivars on the market are simply "strains" picked up in this same fashion.

The searching out of bluegrass selections advanced earlier in Europe than in the United States, largely because of proprietary protection there (a "breeder's rights" law was not enacted in the United States until 1971). Probably because of a more continental climate in most of the United States than in Europe, European selections have often proved less satisfactory than domestic ones for the United States, with occasional notable exceptions ('Fylking' and 'Baron' cultivars, from Sweden and Holland respectively, have achieved top ratings in American tests; 'Sydsport' and others look quite promising at this time). 'Nugget,' an Alaskan find, has proved a particularly interesting case; it reflects its northerly heritage by later growth in spring than other cultivars, but is a top performer of great attractiveness during the long days of summer.

Bluegrasses are to a greater or lesser degree apomictic, seed generally being from an unreduced egg not fertilized by the pollen. The degree of sexuality has been shown to vary, greatly from strain to strain, somewhat (at least in certain cases) with latitude, and with growing conditions (natural outdoor pollination showed less sexuality at Rutgers than forced flowering in the greenhouse). Funk's work clearly indicates that the tendency towards apomixis can be inherited, and that even highly sexual lines can sometimes have their better traits bred into highly apomictic lines to create a desirable hybrid sufficiently apomictic to merit commercial development. Obviously, once an outstanding bluegrass is selected or bred, it is economically most desirable to propagate it and offer it for sale as seed; the seed will come true-to-type only to the extent that the selection is apomictic. Cultivars brought to market are generally highly apomictic, often ninety-seven or ninety-eight percent so (and the remaining small percentage of off-types mostly represent weak recombinations that are overwhelmed in the population). However, the degree of apomixis is evaluated by progeny test, and human judgment enters the picture in deciding whether or not certain of the progeny are "untypical". In some cases qualified experts have disagreed materially about the sexuality of the same cultivar. In any event, for most bluegrass cultivars on the market today the original selection is propagated through seed, and its restricted heredity is preserved through apomixis rather than through clonal separations (although there are a few vegetatively propagated bluegrasses being offered). Rogueing in the seed production fields, and replanting from breeder sources, pretty well keep the cultivars true-to-type.

Sufficient bluegrass selections from nature have been made now, to create quite a bank of select germplasm for the plant breeder to work with. At Rutgers University, for example, hundreds of thousands of selections have been evaluated, most of them discarded, the remainder husbanded for breeding potentialities. Dr. Funk and his students have learned how to achieve crosses even of highly apomictic selections, and have been quite successful in developing a considerable number of hybrids of desirable appearance, performance, disease resistance, apomixis, and so on. It has been found that with most strains that pollination must take place shortly after midnight (in the greenhouse) in order to have male gametes present sufficiently early during egg meiosis to achieve a worthwhile, though small, degree of fertilization. Hot water emasculation has generally proved satisfactory for panicles of the female parent. Many of the hybridizations achieved seem to be of a triploid nature, probably involving an unreduced egg and a reduced male gamete. We won't try to discuss the intricacies of bluegrass genetics here, but the end result of Dr. Funk's work has been for the first time to combine characteristics from select bloodlines in a directed fashion rather than depending upon chance reassortment in nature.

The restricted heredity represented in apomictic lines and hybrids has the same advantages and disadvantages inherent with any crop. To overcome the disadvantages most bluegrass seed is offered in mixture, two or more cultivars or species being combined. That way the risk against some newly mutated disease or other hazard is reduced. Although many of the exclusive "fine points" characteristic of a cultivar are overshadowed in mixtures or multiline seed plantings, the blend should show some adaptability advantages, as in the case of the 'Arboretum' and 'Park' populations previously mentioned.

The situation is a little less involved with fine fescues. Most cultivars are simply selections carried to pure line standards. Until recently fescues were not so intensively collected as bluegrasses and proven bloodlines have been meager. Differences between cultivars seems not so pronounced as with bluegrasses. Most older cultivars such as 'Illahee,' and even new ones such as 'Jamestown,' are nothing more than especially successful clones that were come upon accidentally. 'Pennlawn,' however, represents a deliberate polycross effort involving three parental lines selected at Pennsylvania State University for disease resistance. 'Highlight' and 'Ruby' are European introductions which have adapted well to America, the former a "show" Chewing's fescue (*F. rubra var. commutata*) and the latter a "creeping red" selection (*F. rubra var. rubra*).

Bentgrasses constitute a rather complex group, and experts are still not certain where to place a cultivar such as 'Highland' taxonomically. 'Highland' is a natural ecotype, probably stemming from south German bent introductions, that has proved remarkably successful in the Cascade mountain foothills of Oregon where it has naturalized very effectively. Inexpensive, high quality seed of this cultivar has dominated the colonial bentgrass market in America. 'Astoria' is a similar chance selection from nature, while 'Exeter' represents a more deliberately developed cultivar inbred at the University of Rhode Island (and hence more uniform than 'Highland' or 'Astoria'). Colonial bentgrasses are adapted to humid, maritime locations, and are more used as the underpinning for fine turf in England and northern Europe than they are in continental climates of the United States, although 'Highland' has exhibited good drought resistance.

Creeping bentgrasses have been used mostly for golf greens. By-and-large they have been picked up as unusually successful clones on golf greens in various areas, and are perpetuated vegetatively by the planting of stolons (they do not come true-to-type from seed). Adventive creeping bentgrasses on the Oregon coast have dominated certain localities to become biotypes there, the best known of which is the highly variable 'Seaside.' However, more recently specifically tailored 'Penncross,' a polycross mentioned earlier, has dominated the creeping bentgrass seed market, being more disease resistant than other cultivars, vigorous, and convenient to start from seed. Velvet bents are not widely planted because of the intensive care that they require. However 'Kingstown' is a new inbred from Rhode Island University that shows promise of greater uniformity and easier culture.

The fine-leaf perennial ryegrass cultivars are newly important, used in certain climates alone, and rather generally in small proportion as nursegrasses or for winterseeding. Selections such as 'NK-100,' 'Pelo' and 'Combi' have enjoyed popularity, but perhaps most distinctive is 'Manhattan,' a multiline combination of sixteen clones picked up mostly as ecotypes hanging on in Central Park, New York, by Dr. Reed Funk.

There are no named cultivars of rough bluegrass, *Poa trivialis,* of which seed is imported from Europe for such limited use as the species enjoys on this continent. Redtop has long been utilized as a nursegrass, along with annual ryegrass, and is harvested from unselected adventive stands in the Midwest where it thrives in moist locations.

Thus it is apparent that lawngrass cultivars represent many patterns of origination and practical propagation. Many are simply ecotypes of adventive grass, sorted out by natural selection. Some are honed to a fine edge by elimination of off types through selection and inbred rogueing, their characteristics perpetuated as a pure line or protected through vegetative propagation (including apomixis). Still others are the result of deliberate breeding programs, for which sufficient germplasm has only in recent years become available. The trend is in this direction, with the diversification that has proven useful in lawn culture being obtained through mechanical blending of different varieties or through the polycross technique (where several outstanding selections are planted together and let cross as they will) rather than through use of highly variable, unselected strains. Each "variety" must be considered individually for an understanding of its origin and genetic identity. The accompanying chart summarizes the situation for major American turfgrass species.◇

MAJOR TURFGRASSES OF THE U.S.A.	REPRESENTATIVE CULTIVARS	MAJOR USES	CONSTITUTION	PROPAGATION
Kentucky bluegrasses, *Poa pratensis*	'Arboretum', 'Arista', 'Baron' 'Fylking', 'Merion', 'Nugget', 'Pennstar', 'Prato', 'Sydsport'	lawns and athletic fields; best on good soils and when moderately tended	quite varied and complex genetically; ecotypic, pure line, hybridized, and multiline (partial polycrossing).	mostly highly apomictic seed
Rough bluegrass, *Poa trivialis*	none	damp shade, and winter seeding of golf greens in the South	unselected for homozygosity	seed, not selected for true breeding characteristics
Colonial bentgrasses *Agrostis tenuis*	'Exeter', 'Highland', 'Holfior'	low-mowed turf especially in humid locations, irrigated golf fairways	sexual, ecotypes and selected lines	homozygous and heterozygous seed
Fine fescues, *Festuca rubra* (including var. *commutata*, the Chewing's fescues)	'Cascade Chewing's', 'Illahee', 'Golfrood', 'Highlight', 'Jamestown', 'Pennlawn', 'Rainier', 'Ruby'	in bluegrass mixtures, especially adapted to infertile, light soils and shade	sexual; pure lines in isolation, or occasionally polycross	true-breeding seed
Creeping bentgrasses, *Agrostis stolonifera (A. palustris)*	'Penncross'; vegetative golf green selections such as 'Cohansey', 'Congressional', 'Toronto', etc.	highly kept luxury turf, especially golf greens.	Penncross is a tailored polycross; other seed more heterogeneous	select seed and clonally
Velvet bentgrass, *Agrostis canina*	'Kingstown'	as for creeping bent	inbred line	reasonably homogeneous seed
Perennial ryegrasses, *Lolium perenne*	'Combi', 'Manhattan', 'NK-100', 'Pelo'	quick cover, special maritime locations, and athletic fields where winter not too severe	pure lines and multiline (polycross)	homozygous and tailored polycross seed
Bermudagrass, *Cynodon dactylon* and its interspecific crosses	'Ormond', 'Santa Ana', 'Tifdwarf', 'Tifgreen', 'Tifway'; common	fine lawns and golf greens; common seeded for general cover	strongly sexual and heterozygous heteromorphic from seed	named cultivars clonally; common from heterozygous seed
Centipede, *Eremochloa ophiuroides*	'Oklawn'	minimum care lawns	heterozygous	vegetatively or by unselected seed
St. Augustine, *Stenotaphrum secundatum*	'Bitter Blue', 'Floratine'	lawns of deep South and Gulf area, shade tolerant	variable	clonally and vegetatively
Bahiagrass, *Paspalum notatum*	'Argentine', 'Paraguay', 'Pensacola', 'Wilmington'	coarser lawns of deep South	reasonably pure lines by cultivar	fairly true-breeding seed by variety but heterozygous within variety

The roadway that more or less bissects the show grounds, flanked by flowering cherries . . . the darker strip of grass eventually will be a ground cover of Hypericum 'Hidcote'. *Note the propagating houses in the background.*

A New Concept: The Commercial Botanical Garden

*Frederic Heutte**

The telephone conversation, three years ago, went something like this:

"Mr. Heutte, I wish you would consider the development of a privately financed botanical garden, comparable to the one in Norfolk only smaller, just outside of Elizabeth City, N.C. The property, about thirty acres, lies along the Pasquatank river; it is half wooded, half cleared."

"No. It is flattering to be asked, but, No. I really am enjoying my retirement. Developing the gardens in the two acres at my home is a full time job. Besides, building and developing a botanical garden is a young man's game. It takes years and years just to gather together a suitable collection for such a place."

The conversation continued; I remained adamant. The anonymous investor on the other end of the line tried various arguments. Finally, they came around to the point of serving people with plants. I heard the man say "You're a plantsman; your job is helping people with plants. Come to Elizabeth City to look over the site."

I went to Elizabeth City, determined to steer this man, who obviously wanted to do a job that I wished to see go forward, into a clear course—but without getting too involved personally. He turned my own arguments against me. He talked me into getting to work on the new garden, and I am glad he did.

I had told him that I was too old to assemble the plants needed for a garden. Plants would have to be brought from the great gardens of Europe and from American sources. It would be a time consuming project. I mentioned how we had searched for years, gathering together the unique collection at Norfolk Botanical Garden. I mentioned how sad it was for me, as Director of that Garden, to have to tell visitors that plants they wanted for their gardens were not available, save through the complicated channels we had used. I pointed out that Botanical Gardens make great efforts to gather together the finest species and cultivars of ornamental plants, but few of these find their way into commercial distribution.

My friend—by now, our mutual love of plants had made us friends—took

**Retired Director, Norfolk Botanical Gardens.*

Fred Heutte, gardener, park department superintendent, botanical garden director, founder of horticulture training schools, garden analyst, and, now, seller of unusual plants, has a story to tell. What gardener does not covet a rare or unusual plant for his garden? What gardener does not wish to grow plants not grown before in his neighborhood? Mr. Heutte's latest endeavor has to do with the creation of a "botanical garden-nursery" where unusual and rare plants will be displayed and made available to home gardeners. Home gardening gains by this approach. Here is Mr. Heutte's report.

Part of the 1200 x 20 foot perennial border taken with tulips predominately showing. Robert Hayter, left, will manage the nursery, Fred Heutte is consultant and plant collector. The trees are Koelreuteria paniculata *for a backdrop. These eventually will be a rising out of a four foot ground cover of* Hypericum 'Hidcote', *leaving a six foot grass path to the border.*

The border from the other end, showing the lane on the right, which separates the show and propagating grounds from the nursery growing area (just acquired and started). This acreage will also contain the sales yard, packing sheds and lath houses, as well as ample parking area.

another tack. He pointed out that we could set up a new sort of operation, with a collection of plants, properly displayed, but with a commercial area.

I took him up on that one. I proposed a nursery, with a display garden. We turned it around, and agreed on a botanical garden with a sales area. Though I pointed out that nurseries have to concentrate on "bread and butter" plants, particularly well known and in demand locally, he would not go that route. The idea was to serve the community. Show people something new and exciting. Show plants, properly grouped and properly displayed. And make the plants available. What an idea. My philosophy of serving people with plants could come alive. We could create a standard of beauty with plantings in the new botanical garden, and we could make the plants available. The effect would radiate through home gardens for at least a hundred miles around!

This is an example of the type of lath house being built.

In line with this new idea of encouraging the planting of selected species and cultivars, we determined to help the amateur gardener by supplying him with especially grown plants. When the average gardener buys a plant with which he is not familiar, he is unsure of its requirements, or even, of how to plant it. We will grow our plants in an adequate soil mixture, sufficient for a season's growth, in a container that will disintegrate readily in contact with the soil. The container will be plainly marked to be set at the proper level.

Since March, 1971, development of the new garden has been under way with April, 1973, as a target date for opening. The tract is ideal; thirty acres, just outside the city limits of Elizabeth City. Our thousand foot frontage along the beautiful Pasquatank River, off Albermarle Sound, is in direct communication with the intercoastal waterway. The garden lies five miles inland from Coastal Highway 17, fifty miles south of Norfolk, Virginia.

Our initial planting, made in 1971, was a 1200 foot long perennial border twenty feet in depth. The border is suitably backed with shrubberies. At the same time, fences were planted with screening borders of flowering shrubs and vines.

Around this mighty willow oak (extreme right) is planted a collection of ground covers in "swirls". A statue, life size, yet to be selected, will become the focal point of this display.

A potential aquatic garden.

Also, in 1971, plant collecting was initiated. We still continue to assemble unusual plants—not always plants that are rare, per se, but uncommon in commerce—to be featured in our plantings and to be made available for purchase. In some cases, I have included species that are grown elsewhere in similar climatic conditions, and which I feel will adapt readily to our surroundings.

Our climatic conditions are enviable; we are affected by the gulf stream off shore, but protected by the outer banks. Zone 8, with its semi-tropical temperatures, blends with Zone 7 about one hundred miles north and west of the new garden. We find Spanish-moss, *Tillandsia usneoides,* encroaching on native trees. We feel that we can serve both zones, with choice plants for each. Our annual rainfall averages about forty-five inches. The garden is on sandy loam in the pH 5.5 to 6.0 range.

I anticipate no problem in staffing the new garden and nursery. Trained horticulturalists are available from the schools of practical horticulture in Norfolk and the Sandhills Community College in Southern Pines, N.C., both of which I founded. From the 1972 graduating class at Sandhills, I brought Robert S. Hayter to the new garden. He will develop the nursery operation, and probably will become general manager of the Pasquatank Nursery when we open the gates for commercial operation. I plan to remain on the staff as plant collector and advisor, completing a life-long ambition of making unusual plants available to the average home gardener.

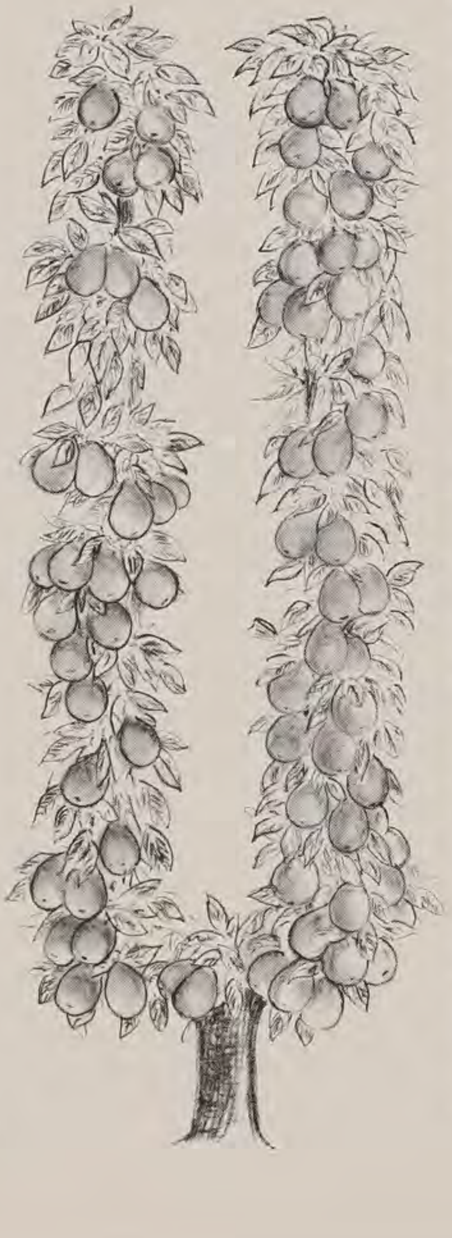
There is the picture, as it presently stands. We are building a nursery. We are building a botanical garden. We plan to display unusual plants in proper landscape schemes, and make the plants available to the public. This is a commercial venture with aesthetic overtones. Most of the long time members of The American Horticultural Society know me, and my work. This is my first entry into commerce; I invite questions and comments from all gardeners who take an interest in our project.

Looking out toward the broad expanse of the Pasquatank River, from which the nursery takes its name. The recently completed boat basin, around which seasonal plants will be displayed will serve as a water front sales yard. The channel is directly connected with the inter-coastal water way. The display area has a 1000-foot frontage on this side of the property (east) all of which has been bulkheaded.

It all started as this.

PRUNING FRUIT TREES THE EUROPEAN WAY

Timothy Timken



Tourists driving from Paris to Versailles may pass through orchards, and the trees scarcely look like fruit trees. From a short main trunk a carefully trained scaffold of branches spreads out on a single plane; it looks as if the trees had been grown against a wall. Actually, they are supported on heavy wires, strung American vineyard fashion, in north-south oriented rows. The trees appear to be dwarf or semi-dwarf; actually, they are standards, dwarfed by pruning. If the tourist visits Jardin Kahn in Paris he encounters another fruit tree collection, formidably trained into columns, pyramids, vases and, again, in single or double, flat, U-shapes. The trees, obviously very old, are of small stature.

Driving north from Venice a visitor passes through commercial orchards; the peach trees are rigorously pruned into low, wide-open goblet shapes; the apples and pears, supported by massive wires, are "flat" trained; a short trunk supports a well spaced scaffold of main branches which produce the short fruiting branches. In Bavaria and throughout Austria every farm house has its espalier-trained pears and apples against the south wall. Fruit trees grown in the same way appear in British gardens.

There is something odd about all these fruit trees. The branches are proportioned in a manner unlike American orchard trees. Leaves are clustered, and there are not many of them. The fruit, usually plentiful, seems to be uniformly dispersed over the stubby, fruiting branches. Each piece of fruit seems to be perfect, with a sun-touched cheek.

The European method of fruit tree pruning sets the pattern of growth, controls the size of the tree, and accounts for the distribution of fruit spurs on the branches. Sometimes, this pruning method is referred to as the Lorette system of pruning. It is a summer technique. Lorette pruning produces trees of restricted size, with interesting, and, incidentally, ornamental, shapes, that bear especially high quality fruit. The system begins with soil preparation, continues through the planting of "maiden" fruit trees (year old, unbranched whips), proceeds through the development of a branch scaffold configuration known to be favorable for the particular cultivar at hand, and depends on annual summer pruning to maintain high productivity. Lorette pruning requires an understanding of fruit tree growth and physiology. Because of the amount of hand labor involved, Lorette pruning probably would not be feasible for commercial fruit production in America. But its application to espalier-trained fruit trees in home gardens could ameliorate the frustration would-be growers of fruit feel when their trees break out in a vigorous burst of leafy growth with never a piece of fruit on the tree.

European fruit tree pruning is based on two operations. The first is carried out in mid-spring, when trees are at full growth, but the growth still is succulent; pruning at this time is limited almost entirely to extension growths, that is, terminal shoots at the ends of branches. The second pruning is a very hard pruning in early summer; timing is critical. The new shoots along the branches must be half-woody. Size is a fair criterion. When an apple or pear shoot is bridge pencil thickness, usually late May or in June, it is time to prune. On very vigorous trees, particularly with young specimens, the operation may have to be repeated again in July, August, and rarely, even in September.

Why summer pruning? With the first flush of vigorous growth in spring, a tree makes a mass of foliage. This foliage acts as the food factory, through photosynthesis, for further growth and for fruit production. When foliage is removed from a plant early in the season, additional growth ceases. Summer pruning, then, represses growth. On the other hand, winter pruning, as carried out in American orchards, reduces the amount of dormant buds that will require water and minerals when spring growth begins. With the upsurge of water and minerals, following spring rains and warm weather, growth is immoderate. Winter pruning results in excessively vigorous growth the following spring.

The first, extension, pruning of the

European system controls branch length. Essentially, this is a "pinching" operation as only a short piece of the new growth is removed in most cases. As a rule of thumb, about one-quarter of the growth of the new extension shoot is cut away. Watch the small buds lying behind the extension shoot on year-old wood; these should be plump. By removing the tip of the extension shoot (sometimes more is taken later), an inhibiting hormone produced by the terminal growth is removed, and lateral buds on the year-old wood will break. Proper pruning during the summer will encourage the formation of fruit spurs at these breaks.

When an espalier-trained fruit trees has reached full, desirable size, extension growth must be absolutely limited. In mid-spring cut away last year's growth, right to its base.

Lateral breaks on year-old wood generally are of two sorts. Those toward the extremity will be leafy, vigorous shoots; those further back are apt to be smaller, almost thorn-like. These latter shoots sometimes are called "darts."

With extension growth accounted for, and lateral growths developing, no more pruning is carried out until the new leafy shoots are half-woody, about bridge pencil thickness. The point of further summer pruning is controlled production of fruiting spurs along year-old, and sometimes older, branches.

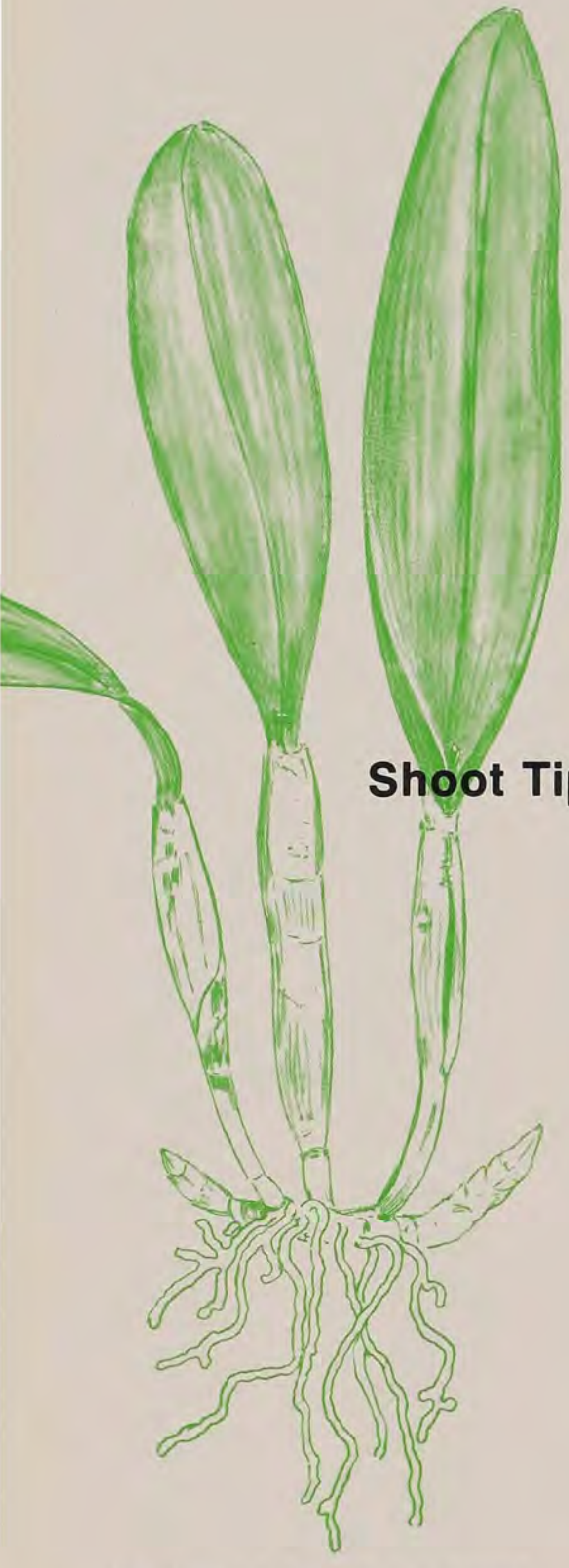
Watch the balance of the new, leafy shoots. After they have reached a length of six inches or more, obviously, some are more vigorous than others. Judiciously nip out the tiny terminal rosette of leaves, including the terminal bud, of the exceptionally vigorous shoots, to maintain a balance of growth among the new shoots. Some growers feel that this balancing out of leafy growth previous to actual pruning is fully as important as the pruning, itself. Others play down the value of early pinching.

With the new growth coming into a half-woody condition, the time has come for the first real pruning. It is severe. Experts use a razor sharp pruning knife because pruning is done at close quarters. A small, well honed secateur will suffice.

A replacement extension shoot may have grown at the end of each branch. Nip out the tip of this, and leave the remainder of that growth intact for the rest of the year. Several leafy laterals will have broken, largely due to the early shortening of the original extension shoot. Notice that these shoots bear one or two quite undersized leaves at the base. Cut the shoots back hard—to stubs of about one-quarter inch in length—with one or two of the small leaves remaining. From the axils of these small leaves or from the wrinkles, which always occur at this point, the small, spine-like growths called darts will break. A certain number of these darts will be transformed into fruit-buds, but most will remain as darts through the summer. Some few will make leafy shoots, and these must be cut back, right to the base, when they are half-woody; usually, about a month later. A year later, many darts will become fruit spurs.

The European system requires that fruit trees be inspected every few weeks throughout summer. Terminal growths remain tied to the supporting framework; leafy lateral shoots are cut back to stubs when half-woody. This is Lorette pruning. There are refinements; some weak, fruit-bearing twigs should be forced to make fruit spurs near the base, and this is done by tying over the weak twig, and by slitting it at about the fourth internode. Darts may be crowded, and some have to be removed. All of these auxiliary operations come clear in actual practice.

Gardeners wishing to try summer pruning, following the European system, should refer to the book "The Lorette System of Pruning," by Louis Lorette, published in several editions during the first three decades of this century. An English translation, by W. R. Dykes, Secretary of The Royal Horticultural Society, was published by Martin Hopkinson & Company Limited, London, in 1925. This translation sometimes appears yet today on used book lists and frequently is found in the stocks of used book dealers.



Orchid propagation traditionally has been accomplished by two methods; raising plants from seed, and dividing mature, or almost mature, plants. Orchids are monocotyledonous plants. Most grow, iris-fashion, with a rhizome (horizontal, modified stem) which produces leaves on the upper surface and adventitious roots on the lower surface. The "front" end of the rhizome usually is growing, actively. Occasionally the rhizome branches. A grower with a strong orchid plant has only to sever the rhizome, making a division with three or four leaves and a few roots, to have a new plant. Adventitious buds develop on the older portion of the original plant, and it, too, soon resumes growth. But this is a slow way of propagating orchid plants.

A recently introduced technique consists of making "cuttings" under sterile conditions of just a few cells. Specialized cells are not suitable for this highly refined method of propagation; rather, clumps of relatively young, unspecialized (undifferentiated) cells are taken from within the bud at the end of the rhizome. These small pieces of tissue are transferred to a sterile culture medium. They can be redissected as they enlarge due to cellular proliferation. Then, by altering the chemical nature of the culture medium, these bits of tissue can be made to go through a series of developmental changes that closely resemble the germination of an orchid seed. Eventually, each becomes a new plant that exactly resembles its parent.

In this article, the first of two, the author reviews the history and background of orchid tissue culture. In the concluding article, actual laboratory procedures, formulae for cultural media, and methods of manipulation will be presented.

Shoot Tip Multiplication of Orchid Clones, Part I

The Status Of "Meristem" Propagation Through 1971

*Frederic J. Bergman**

The hybridization of new orchid cultivars is a slow and costly process. Following pollination, as much as ten years may be required before the first blossoms are produced. The new plant will grow slowly; if it is worthy of clonal propagation, divisions can be made only rarely at first, so that many more years are required to build up a stock for distribution.

By comparison, a rose seedling will bloom about one year after the seed is planted. Even trees and shrubs, once proven, can be propagated rapidly by budding and grafting.

Orchids, like other modern, cultivated plants, are highly heterozygous. It is necessary to raise several thousand seedlings to maturity to obtain a few superior plants. Perhaps one good cultivar may be obtained from a population of 3,500 seedlings. The situation is complicated further because orchid seeds cannot be planted successfully using conventional methods. Although seed production is large (a single pod may contain as many as a million seeds), the fragile seeds must be planted using an aseptic technique. An orchid seed consists of a few undifferentiated cells enclosed in a delicate seedcoat; there is no endosperm tissue to nourish the burgeoning embryo.

Therefore, orchid seeds must be germinated on a medium which contains not only inorganic salts but a source of energy such as sugar. Further, since the medium is rich in nutrients and attractive to bacteria and fungi, it must be sterilized, and the seeds also must be sterilized without damaging the embryos. Seed is sown under sterile conditions.

A brief review of seedling development will provide background information essential to an understanding of vegetative propagation by "meristem" division. The technique proceeds as follows: seed is carefully removed from the capsule, and is sterilized in a solution of calcium hypochlorite. The seed then is sown on a sterile germinating medium (usually, an agar gel) in a

**Mr. Fredric J. Bergman is a research chemist who grows orchids as a hobby. He became enthusiastic about orchid growing when he encountered the University of Missouri collection in 1949. Today, his private collection has expanded to a commercial status, with some six thousand plants. Mr. Bergman presently is an Associate Chemist at Midwest Research Institute, working in the Environmental Sciences Section.*

Mericlone culture begins with gross dissection of a vigorous orchid shoot and is completed under aseptic conditions using microdissection techniques.

Step one is the removal of a new growth; a sterilized scalpel is used. Note that the new shoot is clothed with fleshy, overlapping scales.

The shoot, with outer scales cut away, to expose the succulent inner tissues; each scale represents a modified leaf, and therefore, at the base of each scale there is an axillary bud with undifferentiated tissues. The tip of the scalpel points to such a bud.

Memmler photographs, courtesy Fred A. Stewart, Inc., Orchids.

glass container, and the container is sealed. In three to four weeks the seeds develop chlorophyll, and the cell mass increases without differentiating. By the end of two months a seed will have grown into a small, round, green ball. This structure is called a *protocorm*. Remember that word, as we will encounter it again.

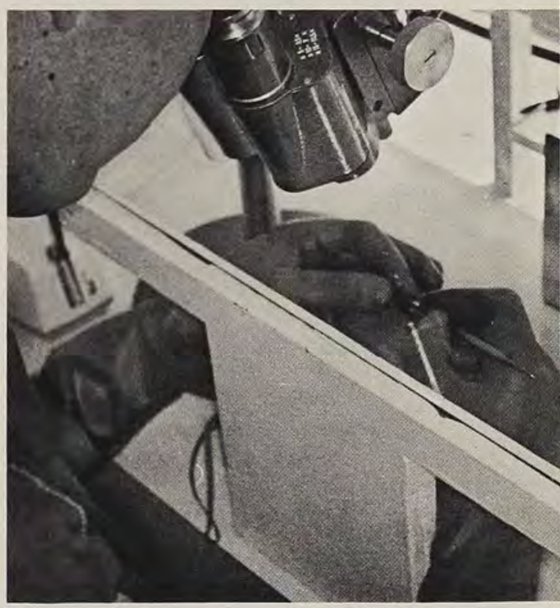
The protocorm then differentiates; it produces rhizoids, followed by the first leaf primordium. The protocorm continues to develop, ultimately producing a small seedling, with true roots normally forming last. Typical orchid seedlings are 6 mm. high in six to twelve months, and at that stage usually they are picked out of the sterile medium and transplanted into a fine-textured potting medium.

Seedlings are repotted at intervals of about one year; they bloom in two to eight years, depending on the species, and on vigor. If a seedling produces outstanding flowers and is selected for marketing, it is divided from time to time; the average production of such a clone is six to twelve divisions every ten years. Because of the time required for production, outstanding new orchid cultivars sell for enormous prices.

A new method of vegatative reproduction was developed about twelve years ago. Mr. Everest McDade is reported to have developed and used the method as early as 1950, but he did not publish his technique but kept it a trade secret. The technique is called, variously, meristem culture, tissue culture or shoot tip culture. Recently Mr. McDade applied for and received U.S. Patent No. 3,514,900 which covers the propagation of orchids by "tissue culture" in the United States.

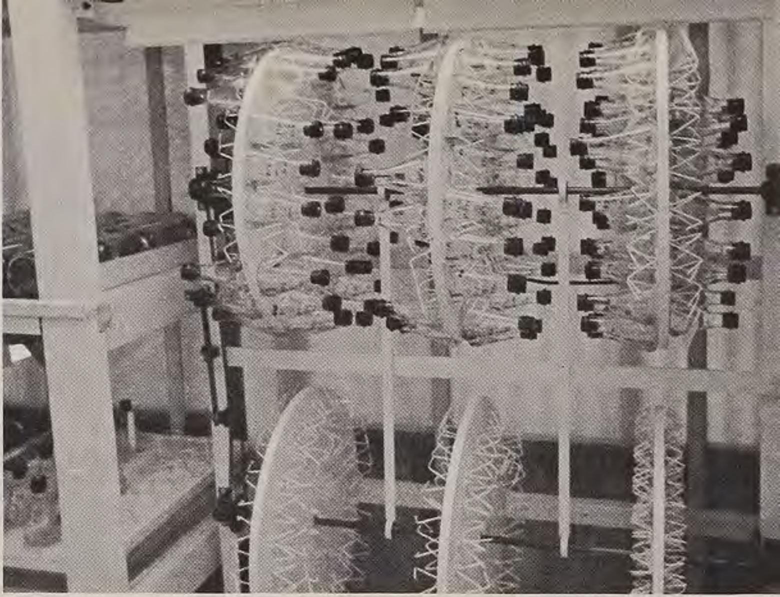
The original published description of orchid propagation by tissue culture was recorded by Professor Georges Morel, who is given a large part of the credit for developing the technique. Earlier Professor Morel had developed tissue culture as a method of freeing select strains of potatoes, dahlias, carnations and hyacinths from viruses. As orchids, too, are infected with viruses, his work extended into this group of plants. During his research with tissue cultures he noticed that occasionally orchid tissues produced protocorm-like bodies which then developed like normal seedlings.

The culture of carefully segrated plant tissues, isolated under sterile conditions, is not new. Stem tips were grown on a sugar containing agar gel as early as 1922, and these eventually produced complete plants. Various



The technician at work; the glass covered box with arm ports reduces spore-carrying drafts; the dissecting binocular microscope enables the technician to observe his manipulations at reasonably high magnifications.

A mass of bud tissue, greatly magnified, held on the tip of a dissecting needle. Sterile conditions must be maintained through the remainder of the operation, as contaminating fungi or bacteria would destroy the orchid tissues in culture.



A shaker apparatus for liquid culture; the Ehrlenmeyer flasks contain sterile nutrient solution; a piece of undifferentiated tissue is placed in each flask, and when the flasks all are "planted," an eccentric cam arrangement agitates the cultures.

A protocorm-like body. Bits of undifferentiated orchid tissue develop into these structures in about six weeks. This chlorophyll-containing mass of tissue closely resembles an early stage in seed germination.

isolated plant cells were brought into culture prior to 1934, and reports published in 1946 describe the development of callus tissue from an excised meristem, with subsequent differentiation of callus tissue into whole plants.

Fourteen years later, Professor Morel published his report, not on a new technique, but on the application of an established technique to orchids. What was new was his observation that orchid tissues occasionally produced protocorm-like bodies that developed like normal seeds, a process that could lead to the rapid reproduction of selected clones.

Soon after Morel's findings were published, Walter Bertsch suggested to the French orchid growing firm of Vacherot and Lecoufle that they should adapt Morel's work to commercial production of orchid clones. At about the same time, Donald E. Wimber initiated his researches on tissue culture as a method of multiplying orchids. He reported that explants (bits of undifferentiated tissue from an orchid bud) grown in agitated liquid media produced many more protocorm-like bodies than explants grown on a gel. With this groundwork laid, refinements of the technique began in numerous laboratories. Morel soon reported that, using the agitated liquid method, an annual production of as many as 4,000 plants from a single explant should be possible, at least in theory.

F. C. Steward, reporting on tissue culture of wild carrot, reported that the ability of tissue to form calli, and then to differentiate and grow into whole plants, could be controlled by the presence or absence of specific hormones and auxins. Morel reported, at about the same time, that protocorms, sectioned as soon as the first rhizoid and first leaf primordium had formed, produce more protocorms from each section. This process may be repeated until the desired number of protocorms are produced at which time sectioning is discontinued, and each protocorm differentiates into a plant. All of this work may be carried out on an agar gel medium rather than in a liquid medium.

Gordon Dillon discussed the "art of using tissue culture to multiply orchids" and reported on several suggested names for the technique. Lt. Gene Crooker, of Patrick Air Force Base, proposed the name "mericlone" which has been accepted generally.

Through the decade of the 1960's mericlone research proceeded along various lines. Commercial orchid growers adapted the technique to their

Proliferation of protocorm-like bodies. When nutrient and growth factor substances are properly manipulated, protocorm-like bodies can be made to proliferate, allowing for further dissection. As each piece potentially is a new orchid plant, this is an important step in rapid increase of a valuable clone.

Undivided clumps of protocorms, showing the beginnings of tissue specialization which results in formation of rhizoids, leaves, and, ultimately, roots. The "plantlets" still can be separated at this stage.

needs. Reports began to come in indicating that mericlone propagations were identical, in flower, to the parent plant, as expected. Vacherot and Lecoufle reported that mericlone propagations of Lc. 'Jocelyn' exactly duplicated the parent, and that mericlones grew faster than the original seedlings, requiring only five weeks short of three years from flask to bloom.

At the present time, Vacherot and Lecoufle are reproducing about 400 orchid clones each year using the mericlone technique. Other commercial producers are operating at a similar scale. Though the original research was done with Cattleya orchids and their immediate relatives and intergeneric hybrids, more genera have been added to the list. Morel's original report on genera yielding successful mericlones included Cymbidium, Cattleya, Miltonia and Phias, with poor results from Phalaenopsis, and negative results with Vanda. With slight modifications in technique, Odontoglossum, Lycaste and Dendrobium soon were added to the successful list, and some degree of success was obtained with Vanda and Paphiopedilum. In 1971 Maurice Lecoufle reported that his company had mericloned Phalaenopsis successfully for two years, and had reduced their failure rate with Cattleya cultivars to one to three per cent.

The actual mechanics of mericloning involve the surface sterilation of an orchid shoot, followed by excission of small bits of non-differentiated tissue from the cell-producing area buried deep in the shoot. The size of orchid shoot used as a source of tissue for culturing does not appear to be critical. Success has been obtained with shoots just starting to grow and with shoots as large as twelve inches long. Many researchers recommend using larger growths so that axillary as well as apical bud tissue may be excised and cultured. This use of larger shoots not only gives rapid multiplication by starting with more than one explant, but also increases the probability of success in the event that one or more of the explants is contaminated.

The size of the excised tissue mass should be as small as possible, to minimize the transmission of virus. There is, however, a lower size limit if the culture is to be successful. Michel Vocherot reported that the smallest explant his technicians have been able to grow was a 0.1 mm. cube of tissue. With Cattleya explants, it has been reported that an explant 5 mm. × 2 to 4 mm. is needed; a few cases are recorded where Cattleya explant cubes 1.0 mm. on the side have been successful.

A new orchid plant, identical to its parent since all of its cells have developed by cell division from parental cells. This almost microscopic plantlet shows, at the base, a fringe of absorbing organs called rhizoids. Part way up, on the left side, a burgeoning root pushes out. Sheathing leaves form the top of the little plant. At this stage, sterile culture is required. When the small plant has made true leaves and a few roots, it can be transferred to open culture in a standard orchid growing medium.

Chrysolepis chrysophylla flowering branch from tree west of Bagley Hall, University of Washington campus.

A Change in Name for the Golden Chinquapin

*Joseph A. Witt**

There are growing on the west coast of the United States two species and a variety of a beautiful relative of the chestnuts and oaks which have the common name of giant, golden and bush chinquapin. These appear all too sparingly in western gardens. This genus of plants was first discovered by that indefatigable plant hunter, David Douglas, in 1826. Douglas recognized the plants as allied to the chestnuts from their fruits and flowers and named them *Castanea chrysophylla*, the golden leaved chestnut.

A further study of these trees and shrubs by A. de Candolle in 1863 showed that their botanical relationship lay more closely with a group of about thirty species of evergreen trees native to the warm temperate regions of Asia, the genus *Castanopsis.* The west coast chinquapins also are evergreen and have flower and fruit characters more closely related to *Castanopsis* than to the genus *Castanea,* the true chestnuts.

As most serious gardeners know, the science of botanical nomenclature is not a static one, and

**University of Washington Arboretum, Seattle, Washington.*

a re-examination of *Castanopsis* by the Swedish botanist Hjelmquist in 1948 indicated that there were a number of subtle but definitive differences which separated the American from the old world species and made them distinct enough to be removed from that genus. He then re-named the Pacific Coast plants *Chrysolepis,* meaning "with golden scales". New names are slow to be accepted even among professional botanists, and it was not until the past few years that the epithet *Chrysolepis* has been used for the American species, but gradually it is now appearing in print.

Regardless if one calls them *Castanopsis* or *Chrysolepis* they are handsome garden subjects and desirable for those who can grow them. *Chrysolepis chrysophylla,* the golden or giant chinquapin, is an evergreen tree reaching a height of over 100 feet tall in southern Oregon and northern California but becoming more shrub-like in northern Oregon and Washington. It is restricted to a very few areas in the latter state. The leathery leaves are slender, up to four inches long, sharply pointed, dark glossy green above and covered on the underside with a thick scarf of golden scales which, of course, give it both its generic and specific name. The inflorescences, which appear in June in Seattle, are clusters of creamy colored spikes that carry the male flowers. In appearance they remind one of a shortened spike of the common chestnut. The female flower, borne at the base of the spikes, develops into a burr about one and one-half inches across, quite like those of the chestnut, that contains up to three sweet edible nuts that take two years to ripen.

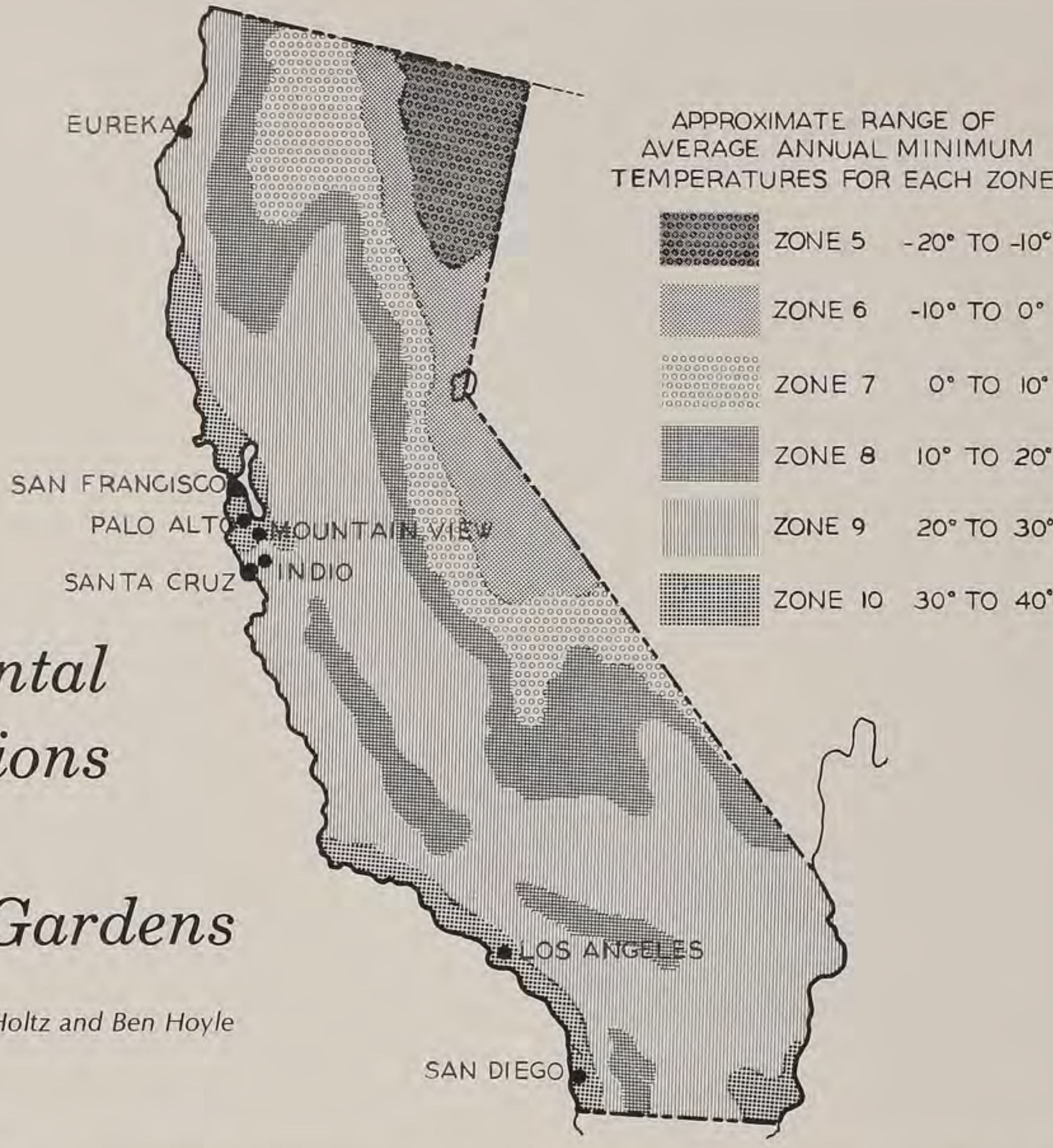
In the mountains of southern Oregon and northern to central California there is a low growing form, *C. chrysophylla* var. *minor,* that rarely reaches a height of more than fifteen feet. The other species of *Chrysolepis* is *C. sempervirens,* the bush chinquapin, a dense rounded shrub with smooth gray bark and

narrow leaves up to three or four inches long, blunt at the apex rather than pointed. Its foliage is gray-green above and either golden or rusty brown beneath with flowers and fruit similar to its larger relatives. It is primarily a plant of the rocky dry slopes in southern Oregon south to central California.

One wonders why such obviously attractive and handsome evergreen plants aren't more widely cultivated. In part the answer lies in the difficulty in transplanting. They will move successfully only when young, and then more successfully from containers. In locating them in the garden it is well to choose a site that at least approaches their native habitat. The two smaller forms make interesting additions to the large rock garden and do best if planted in well-drained poor and rocky soil with full exposure to the sun. They will then develop into neat green mounds which reveal fascinating golden gleams from the under leaf.

The west coast chinquapins are hardy in Zone 7 of the U.S. Department of Agriculture "Plant Hardiness Zone Map" which limits cultivation to the west coast and southern states. As with many California natives, they may have some difficulty in establishing in areas of high summer rainfall since they are accustomed to winter moisture and summer drought in their native home. They would be worth the effort, however, if one could find a course of fresh seed or container grown plants. Few native American trees have such an elegance of form and beauty of leaf as the giant chinquapin, and the two smaller taxa are shrubs of distinction. ⟡

Chrysolepis chrysophylla *tree, University of Washington campus, fifteen feet tall.*



Environmental Variations in California Gardens

Charles Holtz and Ben Hoyle

California gardeners find that a great deal more affects horticulture in this state than meets the eye. No state in the Continental United States has as many variations in temperature and elevation. Naturally, the comparative hardiness of plants depends on many factors, but the average minimum temperature of the coldest month is undoubtedly the leading one. Many years ago, Mr. Alfred Rehder of Boston's Arnold Arboretum mapped out the country by temperature zones, using a scale of Zones 1 to 8, later augmented by Zone 9, which would apply to the Southern tip of Florida. Using this scale, Iowa, for example, is practically entirely in Zone 2, with an average length of 168 days in the growing season. California, in contrast, is zoned from 4 to 8, with growing seasons varying from less than one hundred to well over 300 days, the latter being at the Zone 8 end of the scale. Average dates of last killing frosts in spring vary from January to June, while the average first killing frosts in autumn vary from early September to late December. Actually, however, frost can and does occur on any day of the year in the High Sierra or the Siskiyous, as any of us who've camped there can testify, and conversely, the San Diego Area often escapes frost entirely.

It should be noted that although some areas are frost-free, growth usually ceases below approximately 40°F.; hence the seeming discrepancy between length of growing seasons and the 365 days in the calendar year.

Unlike most states again, the temperature zones tend to lend themselves more to a north-south configuration, due to the effects of the mountain ranges, the extensive seashore and the Japanese Current off-shore. Thus, the number of days above freezing varies from a typical 365 days in San Diego, Santa Barbara, Santa Cruz and San Francisco, to less than one hundred such days in the high mountains. In a more subtle way, the great length of the coast line is affected by distance from the Equator, even though greatly modified by the seashore. While the so-called frostless pockets extend along the coast from Mexico to Sonoma County north of the Golden Gate, there is a very apparent difference in the same species of plants when grown in San

Diego and when grown in San Francisco due mostly to the difference in mean average temperature. Inland areas often record much higher average annual temperatures, but the winter temperatures are too low to sustain sub-tropical plants such as hibiscus, bougainvillea or poinsettia. These grow well in the frost-free coastal areas, where artichokes are grown commercially.

Here humidity plays another large part. Although native Californians are always overwhelmed by the stifling Eastern summers, the West's coastal areas also have a high humidity, but generally lack the corresponding high temperatures. For example: Los Angeles has a daily relative humidity range of fifty-one to seventy-seven percent, San Francisco sixty-four to eighty-five percent, and Eureka on the north coast, seventy-nine to ninety-one percent. The lower humidity inland, as Fresno's thirty-nine to seventy-three percent, makes the hot summers more tolerable to humans, but the dearth of humidity produces sunburn on many imports such as the Japanese maples, birch, beech, and of course, both the coastal and the giant redwood trees. California's commercial date plantations are largely concentrated in the Indio area with an average annual temperature of 73°F., but a very low humidity. It is interesting to note that while these palms will grow in Florida, the high humidity there precludes the setting of fruit.

Soils also vary exceedingly in texture and nutrient value in California, ranging from heavy clay to lightest sand, and soil may vary considerably even on small plots. Most California mountain soils are acid, many horticultural soils are comparatively neutral, while great areas (particularly in desert regions) are alkaline, toxic to many plants unless amended with soil correctives. Mountainous and hilly areas tend to have soils of porous, decomposed granite structure with excellent drainage, varying in color from "Georgia Red" in the foothills of the

A field of tuberous begonias, Santa Cruz, California.

Commercial date orchard near Indio, California.


White wisteria in a private garden at Palo Alto, California.


Home-grown vegetables at Mountain View, California.

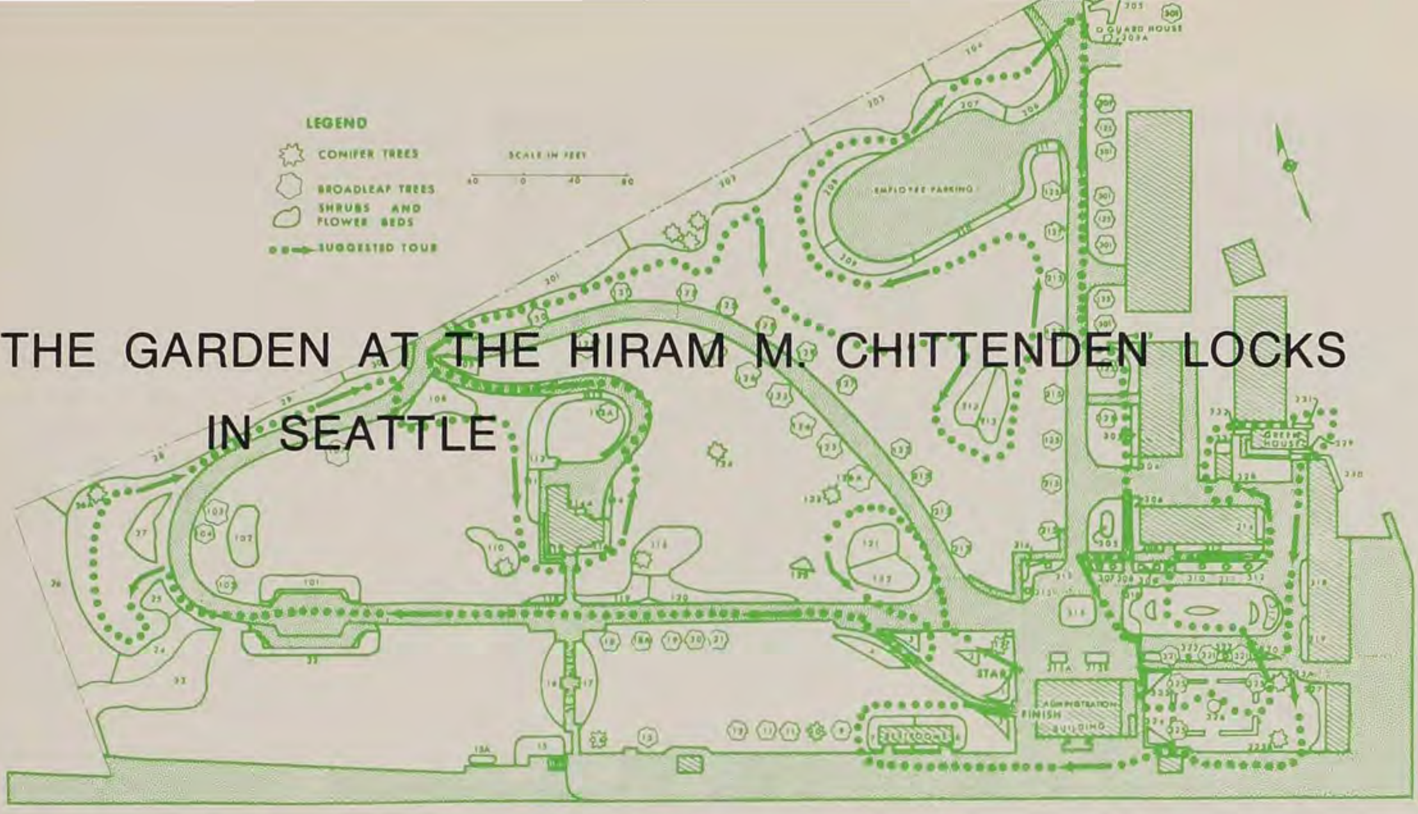
Coast Range and Mother Lode country to the very light gray of the High Sierra. Down through the great valleys lie the endless miles of rich, sandy, loam where the bulk of the field crops are grown; and as we approach present-day San Francisco Bay, the soil becomes increasingly fine, heavy and dark, until we reach the black adobe so familiar in the garden and orchard land of Santa Clara Valley, alas now largely planted to endless apartment buildings, industrial complexes, parking lots and ribbons of concrete and asphalt. The vast, sandy deserts of the southern parts of the state, lacking water, need just that priceless ingredient to make them bloom, as exemplified by the Imperial Valley and its crops.

While we, here in the Bay Area must pick our backyard tangerines before they become overripe in February, the Sierra is slumbering under a ten-foot load of snow; and when we are picking our backyard loquats in May, 250 miles away at Lake Tahoe, the lilacs and flowering plums are still dormant, with not a leaf or flower showing.

Rainfall varies as greatly as does the topography, with practically all precipitation occurring during the winter and early spring. This varies from no rainfall in some years in desert areas, to amounts in excess of one hundred inches along the northern coastal areas.

Fog, generated along the coast, acts as an effective sun filter, where the world-renowned tuberous begonias, primroses and fuschias are at their prime. Steady ocean winds have molded the shoreline trees such as the famous Monterey cypresses at Pebble Beach. Southern California is frequently further desiccated by the stirring desert wind known as the Santana.

It can readily be seen that California is a land of contrasts from Oregon to Mexico—from the Pacific to the Sierra, and from Death Valley to Mt. Whitney. It is a land of many environments that permit culture of a very wide range of plants.



THE GARDEN AT THE HIRAM M. CHITTENDEN LOCKS IN SEATTLE

*Carl S. English, Jr.**

Trying out plants that are new to cultivation is a great challenge and stimulus to the horticulturist because it keeps him alert and full of anticipation. The Puget Sound area is a wonderful place in which to conduct the research necessary to progress in the field of ornamental horticulture.

Plants in the Collection

The locks garden includes a fair-sized collection of the family, *Ericaceae*, with a fine representation of rhododendrons. These, together with magnolias, flowering cherries, crabapples, dogwoods and many other flowering trees and shrubs offer a pleasing attraction in the spring floral display.

The evergreen oaks of the genus, *Quercus*, are well represented and have involved much exploration and research. Many desirable species of this genus are found growing natively in the western and southwestern part of the United States. The grounds now display many large evergreen oaks that were grown from seed collected in these areas. These trees are now producing acorns abundantly for another generation.

Of special interest is a twenty-foot, forty-year-old pistillate tree of *Trachycarpus fortunei*, the oriental fan palm, grown from seed at the grounds. As a result of pollination by a younger staminate tree it has borne a number of heavy seed crops. Unfortunately the fruit is not edible. Numerous seedlings from this tree are now thriving.

Some of the important genera to be seen in the locks garden include: *Acer, Actinidia, Aesculus, Akebia, Albizia, Aralia, Arbutus, Bouvardia, Bupleurum, Callistemon, Camellia, Carpenteria, Ceanothus, Cercidiphyllum, Chamaerops, Chimonanthus, Choisya, Cornus, Corylopsis, Dasylirion, Dendromecon, Dendropanax, Embothrium, Eucryphia, Fallugia, Fraxinus, Fremontia, Garrya, Gunnera, Hamamelis, Libocedrus, Lithocarpus, Magnolia, Mahonia, Metasequoia, Nothofagus, Olearia, Parrotopsis, Poncirus, Pseudolarix, Quercus, Sciadopitys, Stauntonia, Stewartia, Styrax, Trachycarpus, Trochodendron* and *Umbellularia*.

The two main sources of plants have been, first, my private exploration of our western and southwestern states for seeds of native species and second, seed exchange with many foreign botanic gardens and with citizens of many countries. Excellent plants have come through exchange with the University of Washington Arboretum as well as with the National Arboretum.

Eighty per cent or more of the original plant material of the locks garden has, over the years, been replaced by new and more desirable kinds. Al-

**The gardens at the Hiram M. Chittenden Locks, in Seattle, Washington, are the work of Mr. Carl S. English, Jr., who has directed their development and maintenance for more than forty years. At the 1971 American Horticultural Society Congress, in Milwaukee, Wisconsin, Mr. English was awarded the A. H. S. Citation for Professional Horticulture. The Locks gardens will be featured during the 1972 A. H. S. Congress in Seattle, in September.*

View toward the Administration Building with Aesculus californica *and, in the foreground,* Acer platinoides, *the Norway maple.*

Shrub border with Pinus sabiniana, *the digger pine, at right.*

Shrub border with Malus floribuda.

though the garden is mainly one of outstanding trees and shrubs, quite a variety of unique herbaceous plants has been included.

Personnel, Facilities and Programs

While there never has been an excessive budget for the grounds, on the other hand, fortunately, I have been granted a free hand in developing the planting. The garden force consists of two persons with an extra summer helper two or three days each week.

A small greenhouse and nursery area provide facilities for propagating all plant material used on the grounds and cut or growing material for the residence of the district engineer and the administrative offices at the locks.

Now that so many of the plant introductions have matured over the years, local garden-minded persons, as well as those from afar, come to the locks grounds to study plant materials. An effort is made to have something of interest at all times of the year beginning with the winter-blooming shrubs, then the spring abundance of bloom of both trees and shrubs, followed by the summer bloom of the annuals and the late-blooming trees and shrubs, and closing with soothing colors of the autumn leaves.

In 1969 on the occasion of the International Botanical Congress, held in Seattle, a brochure for a self-guided tour of the locks grounds was published by the Corps of Engineers for the benefit of visiting botanists and students. This publication helped greatly by supplying a map of the grounds and identifying the plants by bed or location.

University classes, Arboretum units, garden clubs and other groups enjoy the free tours of the locks grounds, personally conducted by myself during the various seasons. These tours which require about an hour's time, give the visitors an opportunity to see and become acquainted with plants of outstanding quality. Reservations are made for each group, often a year or more in advance.

History of the Garden

It is noteworthy that when the U.S.

Army Corps of Engineers undertook the construction of the Lake Washington Ship Canal and the Hiram M. Chittenden Locks, connecting Puget Sound with Lake Union and Lake Washington, an area of seven acres was set aside for the location of one residence and for landscaped grounds. The garden was first constructed in 1932.

Construction of the locks began in 1911. The residence, originally established as a civilian domicile for the engineer in charge of the locks and the canal, has in later years become the residence of the district engineer.

Landscaping of the grounds began in 1916. The first plant material, furnished by the Seattle Park Department, consisted of trees and shrubs that were in vogue at that time. This material included the common, very hardy plants that were widely used in eastern states. Much was to be learned about rainfall, temperature, orientation, soil conditions and their favorable effect on growing conditions in the Seattle area. In addition, a very brisk change in nursery stocks, including the introduction of unusual species, was to improve the character and selection of available ornamental plants. At the locks garden real effort has been put forth throughout the years to keep abreast of this movement by continually acquiring new kinds of plants to try out and dispersing the choicer ones to worthy institutions and individuals.

Site and Environment

The locks grounds are adjacent to Puget Sound, the water temperature of which varies little the year around. For this reason the locks garden seems to be as favorably located as almost any part of the Seattle area.

Frost scarcely ever occurs here after the first of April or before the first or second week of November. It is interesting to note that in areas only a few miles inland frost is likely to appear well into May and begin again in September. Within a distance of twelve to fifteen miles inland from the salt water the winter weather is quite consistently ten degrees colder than that at the locks. While two or three successive winters with temperatures not lower than 28°f. have been recorded, other years may offer winter temperatures that dip as low as 16° to 10°f. at the locks. Over a number of years these freezing periods become one of the limiting factors that determine which plants can survive.

Although low winter temperatures are not extreme in Seattle, neither are the summers very hot. The moderate, often rainy, summers tend to eliminate plants that require long, hot periods. With the temperature advantage it is possible at the locks garden to succeed with many marginal plants that will not be seen in colder areas.

Seattle's average rainfall of 34 inches, together with glacial soil, produce an acid condition which, of course, is favorable to the many lovely acid-loving plants grown at the locks garden.

During the grading of the locks grounds, the slopes, bank, and gradients all were wonderfully planned; but the fill soil condition has caused severe horticultural problems. As glacial soil goes, the original soil at the garden site is not too unsatisfactory, being a sandy loam with gravel. However, only a few square yards with the original top soil in place were left undisturbed.

The hill part was leveled by several feet and the flat, lower part was filled in with dredged material, neither of which could be considered the ideal place on which to establish a garden of trees and shrubs. As a result the hill area has no drainage or subsoil to absorb rain water. Five or six inches of top soil were put back on this area in order to establish a lawn. While the lawn has thrived, for any successful tree or shrub planting it has been necessary to excavate and bring in new top soil.

In order to create a garden such as the one at the locks grounds it is essential to have knowledgeable employees with ample horticultural training, a true appreciation of the aims to be accomplished, and a free hand in the development of the garden. I have had the pleasure of fulfilling my hopes of developing a garden that not only would be a joyous sight to see but also a garden worthy of serious study.

A mature planting of Rhododendron molle.

Photographs courtesy United States Corps of Engineers

Rhododendron and Kalmia in the shrub border.

The original plant of Ilex x *'Lydia Morris'* (I. cornuta *'Burfordii'* x I. pernyi) *was nine feet tall and nine feet wide at seventeen years of age.*

Holly Hybridization at the National Arboretum

*Gene K. Eisenbeiss and Frank S. Santamour, Jr.**

Interspecific hybrids in *Ilex* are not new to cultivation. Loudon (1838) described *I. aquifolium* L. 'Altaclerensis' (a male clone), which was later recognized to be a putative natural hybrid between *I. aquifolium* and *I. perado* Ait.. This cross was given the collective hybrid epithet of *I.* x *altaclarensis* by Dallimore and further critical investigation showed that numerous other cultivars, of both sexes, were derived from this hybrid combination. Other natural hybrids, such as *I.* x *koehneana* Loes. (*I. aquifolium* x *I. latifolia* Thunb.) and *I.* x *attenuata* Ashe (*I. opaca* Ait. x *I. cassine* L.), were also recognized during the latter part of the 19th century and early part of the 20th century.

The dioecious nature of *Ilex* and the wide range of cultivated species available did not evoke much interest in controlled hybridization among botanists or horticulturists until the mid-1900's. This work was first initiated and has continued to this day to be concentrated largely along the East Coast of the United States. The U.S. National Arboretum has been intimately associated with holly breeding since its inception.

The earliest attempt at controlled interspecific crossing in *Ilex,* for which we have records, was made by Oliver M. Freeman, botanist at the U.S. National Arboretum, in 1929. He obtained six seedlings from the cross of *I.*

**Horticulturist and Research Geneticist, respectively, U.S. National Arboretum, Plant Science Research Division, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C. 20002.*

opaca x *I. aquifolium,* but left no data regarding the authenticity of the progeny. During the period 1940-1945, Mr. Freeman attempted thirteen more interspecific crosses, among which only *I. opaca* x *I. cornuta* Lindl. was assumed to be a true hybrid. Unfortunately, there are presently no living plants or herbarium specimens by which we can verify these hybrids.

To the best of our knowledge, the first control-pollinated interspecific holly hybrid, verified by records and existing plant material, was created by Henry T. Skinner in 1948. At that time, Dr. Skinner was Curator of the Morris Arboretum of the University of Pennsylvania in Philadelphia. Skinner (1952) listed thirty-three attempted crosses in his hybridization program, among which the 1948 cross of *I. cornuta* 'Burfordii' x *I. pernyi* Franch. and the 1949 cross of *I. myrtifolia* Walt. x *I. opaca* were unquestionably successful. Seedlings of both hybrids were brought to the National Arboretum in 1952 when Dr. Skinner became Director of that institution. After several years of evaluation, two cultivars of the 'Burfordii' x *I. pernyi* cross, 'Lydia Morris' (H.S.A. Reg. No. 7-61) and 'John T. Morris' (H.S.A. Reg. No. 8-61) were selected, named, and registered with the Holly Society of America, Inc.*

William F. Kosar came to the National Arboretum in 1955, and in collaboration with Francis deVos, Assistant Director of the Arboretum, carried out exploratory holly hybridization during 1956. The new interspecific hybrids achieved that year were *I. opaca* x *I. aquifolium, I. cornuta* x *I. aquifolium,* and *I. glabra* (L.) Gray x *I. serrata* Thunb., as well as a number of tri-specific combinations.

This initial experimentation and evaluation of the potential value of hybridization in *Ilex* led to the establishment of a formal breeding project in hollies. Dr. deVos turned his attention to other genera, and the responsibility for the holly project was given to Mr. Kosar, who led the project from 1957 until his retirement in 1971.

During this period, Mr. Kosar assembled an unparalleled collection of holly germ plasm (some sixty-four species and 696 botanical varieties and cultivars) and originated more control-pollinated holly hybrids than any other breeder. The genetic improvement of woody plants is a long-term undertaking, and it was not until 1965 that the first new hybrid cultivar from his work was registered. Two female cultivars, 'Tanager' (H.S.A. Reg. No. 3-65)** and 'Oriole' (H.S.A. Reg. No. 4-66)*** *were selected from an* F_2 cross based on Dr. Skinner's original *I. myrtifolia* x *I. opaca* hybrid. The cross of *I.* 'Nellie R. Stevens' (*I. aquifolium* x *I. cornuta*)x *I. leucoclada* Mak. gave rise to the female cultivar 'Clusterberry' (H.S.A. Reg. No. 3-66)***. A male cultivar, 'Accent' (H.S.A. Reg. No. 7-66)***, and a female 'Elegance' (H.S.A. Reg. No. 6-66)***, were selected from the cross of *I. integra* Thunb. x *I. pernyi.* The artificial crossing of *I. aquifolium* x *I. latifolia* (*I.* x *koehneana* as a natural hybrid) produced the female 'Ruby' (H.S.A. Reg. No. 3-67)**** and male 'Jade' (H.S.A. Reg. No. 4-67)****. All of these cultivars represent distinct improvements over existing types for many sites and landscape uses.

These named and registered cultivars are only the beginning. Thousands of seedlings have been raised and evaluated. More than two hundred clones have passed the initial selection process and have been propagated in small numbers for testing at various locations throughout the United States. The full importance of Mr. Kosar's work may not be realized even in the next decade. The evaluation of these hybrid hollies, as well as some supplementary hybridization work, will continue to occupy the present authors for many years to come.

During our current over-all evaluation of the holly project, it became obvious that not only were the plant materials of great importance, but also that much of the scientific data compiled by Mr. Kosar were worthy of dissemination. Therefore, in this paper, we have assembled the pertinent information regarding the attempts to produce only first-generation interspecific hybrid combinations in *Ilex*. The crossability patterns in the genus as derived from Mr. Kosar's extensive work should be

**Registration Committee Report, Proc. 31st Mtg. Holly Soc. Amer. pg. 11., 1961.*

***Report of the registration committee. Proc. 38th Mtg. Holly Soc. Amer., pg. 12. 1965.*

****Report of the holly registration committee. Proc. 41st Mtg. Holly Soc. Amer., pg. 13. 1966.*

*****Report of the holly registration committee. Proc. 42nd Mtg. Holly Soc. Amer., pg. 18. 1967.*

of interest to present and future amateur and professional holly breeders, as well as geneticists and taxonomists investigating plant relationships and classification.

Background information on the rationale and techniques of holly hybridization is contained in papers by Kosar (1957) and Orton (1970). In relegating species to taxonomic sections, we have used the generic classification scheme of Rehder (1940) as the basic standard, with those of Loesener (1901) and Hu (1957) as supplementary references. Differences between classification systems are noted where appropriate.

Almost all of the controlled pollinations reported here were performed on stock plants growing indoors in a cool greenhouse. Many holly species, when grown outdoors in the Washington, D.C. area, have very brief flowering periods, sometimes only a few days. By growing these plants in containers in the greenhouse, the flowering season was extended from several weeks up to three months. The use of cold storage facilities allowed further manipulation of flowering times. Thus by careful attention to details, it was possible to use fresh pollen for the majority of the crosses.

There are many "blanks" in the tables and listings that follow. It was not Mr. Kosar's intention to determine a "full" pattern of crossability, where each species was crossed with every other species in a particular group. Rather, he tried to aim his hybridization program toward certain breeding goals. Furthermore, we have not included data on the many successful intraspecific crosses (between cultivars or individuals of the same species) or the multitude of advanced generation crosses utilizing natural and artificial hybrids to create new combinations involving three, four, five, or six different species. These multi-species crosses constitute an impressive body of work, and may be the subject of a future publication.

The key designations in the tables and listings that follow are: (F) = Failure—no seeds produced; (P) = Possible—seeds produced but no germination, or, if seedlings developed, of undetermined hybridity at present; (H) = Hybrids—verified interspecific hybrids obtained.

The reporting of failures or "possibles" is not a common practice in genetics studies, but the authors believe it is important both to show the scope of past efforts and to point the way toward future work that will undoubtedly alter and clarify the species crossabilities in *Ilex*.

Results and Discussion

In Table 1 are listed the results of crossing among the ten most widely used holly species of Sect. Aquifolium Maxim. Nineteen combinations produced good hybrids, twenty gave indications of crossability, and only five crosses failed completely. It is significant that four of the five failures involved *I. vomitoria* Ait., a species which has been classified in a separate section (Microdontae) by Loesener (1901). The other failure was *I. aquifolium* x I. cornuta, but the reciprocal (*I. cornuta* x *I. aquifolium*) was successful. It should be mentioned that, since *Ilex* is dioecious, "reciprocal" crosses can never involve the same parent genotypes. The genotypes of the individual parents are the most critical factors in crossability, and this must be borne in mind when interpreting the success or failure of the interspecific reciprocal crosses noted above. With the exception of *I. vomitoria,* the species in Sect. Aquifolium comprise a

**dioecious* = with sexes on separate plants; i.e. a holly plant produces all male or all female flowers.

William F. Kosar, holly breeder at the National Arboretum (1956-71), performs controlled pollinations in the greenhouse.

Ilex x *'Elegance', a cross of* I. integra x I. pernyi.

Ilex x *'Oriole', a selection from an F_2 population of the cross* I. myrtifolia x I. opaca.

Ilex x I. koehneana *'Jade' is a male cultivar of the cross* I. aquifolium x I. latifolia, *and extends the hardiness range of large-leaved hollies.*

Photographs courtesy United States National Arboretum fairly natural grouping, and it is likely that all species in this Section can be intercrossed with relative ease.

Species belonging to Sect. Lioprinus Loes. appear to constitute a genetically heterogeneous grouping. Among the ten species listed in Table 2 are three that normally produce black, rather than red fruit: *I. coriacea* (Pursh.) Chapm., *I. crenata* Thunb., and *I. glabra*. *I. pedunculosa* Miq. is reported to have a diploid chromosome number of $2n=110$, in contrast to $2n=40$ recorded for nineteen other species (Frierson, 1959). Hu (1957) retained *I. chinensis* Sims in Sect. Lioprinus, but placed other related species (*I. crenata, I. sugeroki* Maxim., etc.) in another Section (Paltoria).

Therefore, although we can logically expect to encounter some crossability barriers among species in Sect. Lioprinus, the work reported in Table 2 is not sufficiently complete to permit any valid judgements on crossability patterns.

In addition to the intrasectional crosses reported in Tables 1 and 2, a few other attempts have been made with some of the less common species. These are listed below, along with some crosses involving species of disputed sectional status:

I. anomala var. *sandwiciensis*	x	*I. latifolia*	(P)
I. ciliospinosa	x	*I. fargesii*	(P)
I. corallina	x	*I. aquifolium*	(F)
I. cumulicola	x	*I. myrtifolia*	(P)
I. cumulicola	x	*I. opaca*	(P)
I. georgei	x	*I. aquifolium*	(P)
I. paraguariensis	x	*I. vomitoria*	(P)
I. perado var. *platyphylla*	x	*I. colchica*	(P)
I. perado var. *platyphylla*	x	*I. aquifolium*	(P)
I. rugosa	x	*I. corallina*	(P)
I. vomitoria	x	*I. corallina*	(F)

Intersectional crosses, between species belonging to Sections Aquifolium and Lioprinus are listed in Table 3. Only two verified hybrids, *I. crenata* x *I. intricata* and *I. opaca* x *I. aquifolium,* have been produced at the Arboretum. Thirteen attempted intersectional crosses have failed to produce seed. Obviously, the genetic barriers to intersectional hybridization, while not complete, are stronger than those between species within sections.

Hybridization with deciduous hollies (Subgenus Prinos Gray) has been quite limited (Table 4). As mentioned above, *I. glabra* was successfully crossed with the deciduous *I. serrata* in 1956. Five hybrid plants were obtained, but they were all sterile. Female plants failed to set fruit even when control pollinated with pollen of the parental species. On the other hand, *I. decidua* Walt. of Sect. Prinoides Gray has produced fertile hybrids when crossed with *I. aquifolium* and *I. latifolia* of Sect. Aquifolium and with *I. opaca* of Sect. Lioprinus. These deciduous x evergreen hybrids behave like evergreens in the Washington, D.C. area, and are being used to create new hybrid combinations with increased hardiness.

In Table 5 we have summarized the verified F_1 interspecific hybrids made during the period 1956-1969. The crosses are listed alphabetically, by female parent. Reciprocal crosses are also included in this list and the year that each successful cross was obtained is noted.

Holly hybridization research at the National Arboretum has, largely through the work of William F. Kosar, provided valuable breeding data and a legacy of plant materials for future evaluation and experimentation in the decades to come.

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Table 1. Primary interspecific hybridization in *Ilex* Sect. Aquifolium Maxim.

	Male Parent									
Female Parent	*I. aquifolium*	*I. ciliospinosa*	*I. cornuta*	*I. integra*	*I. latifolia*	*I. leucoclada*	*I. perado*	*I. pernyi*	*I. rugosa*	*I. vomitoria*
I. aquifolium	—		F		H		P			P
I. ciliospinosa	P	—							H	
I. cornuta	H	P	—	H	H	H		H		P
I. integra	H		H	—	P	H		H		F
I. latifolia						—		P		
I. leucoclada				H	·	—		H		
I. perado	P				P		—	P		
I. pernyi	H		P	H	H		H	—		P
I. rugosa	P		P	H	P	P		P	—	P
I. vomitoria	P		H	F	F			F	P	—

Table 2. Primary interspecific hybridization in *Ilex* Sect. Lioprinus Loes.

	Male Parent									
Female Parent	*I. cassine*	*I. chinensis*	*I. coriacea*	*I. crenata*	*I. glabra*	*I. myrtifolia*	*I. opaca*	*I. pedunculosa*	*I. sugeroki*	*I. yunnanensis*
I. cassine	—			F	P	P	H			
I. chinensis		—		P					P	
I. coriacea			—		H				H	
I. crenata		P	P	—					H	H
I. glabra		H	H	H	—			F	H	F
I. myrtifolia	P					—	H			
I. opaca	H		F	F	F		—			
I. pedunculosa					P			—		
I. sugeroki		P	H	H	P	F			—	P
I. yunnanensis				H	P				H	—

Table 3. Primary interspecific intersectional crosses involving species from *Ilex* Sect. Aquifolium and Sect. Lioprinus.

Female parent		**Male parent**	
I. cassine	x	*I. ciliospinosa*	(F)
I. cassine	x	*I. latifolia*	(F)
I. cornuta	x	*I. myrtifolia*	(P)
I. crenata	x	*I. corallina*	(F)
I. crenata	x	*I. intricata*	(H)
I. crenata	x	*I. rugosa*	(F)
I. crenata	x	*I. vomitoria*	(P)
I. cumulicola	x	*I. aquifolium*	(P)
I. myrtifolia	x	*I. aquifolium*	(P)
I. opaca	x	*I. aquifolium*	(H)
I. opaca	x	*I. cornuta*	(F)
I. opaca	x	*I. latifolia*	(F)
I. pedunculosa	x	*I. ciliospinosa*	(P)
I. pedunculosa	x	*I. leucoclada*	(P)
I. perado	x	*I. glabra*	(F)
I. rugosa	x	*I. crenata*	(P)
I. rugosa	x	*I. yunnanensis*	(F)
I. sugeroki	x	*I. aquifolium*	(F)
I. sugeroki	x	*I. pernyi*	(F)
I. sugeroki	x	*I. rugosa*	(F)
I. sugeroki	x	*I. vomitoria*	(F)
I. vomitoria	x	*I. sugeroki*	(F)

Table 4. Primary interspecific crosses involving deciduous holly species.

Female Parent		**Male Parent**	
I. ambigua	x	*I. pubescens*	(P)
I. aquifolium	x	*I. decidua*	(P)
I. crenata	x	*I. decidua*	(P)
I. decidua	x	*I. aquifolium*	(H)
I. decidua	x	*I. crenata*	(P)
I. decidua	x	*I. glabra*	(F)
I. decidua	x	*I. latifolia*	(H)
I. decidua	x	*I. opaca*	(H)
I. glabra	x	*I. serrata*	(H)
I. glabra	x	*I. verticillata*	(F)
I. laevigata	x	*I. glabra*	(P)
I. laevigata	x	*I. verticillata*	(P)
I. nipponica	x	*I. pubescens*	(P)
I. nipponica	x	*I. serrata*	(P)
I. serrata	x	*I. verticillata*	(H)
I. sugeroki	x	*I. serrata*	(P)
I. sugeroki	x	*I. verticillata*	(F)

Table 5. Summary list of all verified F_1 interspecific hybrids made by Wm. F. Kosar at the National Arboretum, 1956-1969.

Female Parent	**Male Parent**	**Year**
I. aquifolium	*I. latifolia*	1956
I. cassine	*I. opaca*	1960
I. ciliospinosa	*I. rugosa*	1960
I. coriacea	*I. glabra*	1964
I. coriacea	*I. sugeroki*	1962
I. cornuta	*I. aquifolium*	1956
I. cornuta	*I. integra*	1965
I. cornuta	*I. latifolia*	1962
I. cornuta	*I. leucoclada*	1961
I. cornuta	*I. pernyi*	1958
I. crenata	*I. intricata*	1969
I. crenata	*I. sugeroki*	1963
I. crenata	*I. yunnanensis*	1964
I. decidua	*I. aquifolium*	1958
I. decidua	*I. latifolia*	1958
I. decidua	*I. opaca*	1958
I. glabra	*I. chinensis*	1967
I. glabra	*I. coriacea*	1962
I. glabra	*I. crenata*	1962
I. glabra	*I. serrata*	1956
I. glabra	*I. sugeroki*	1962
I. integra	*I. aquifolium*	1960
I. integra	*I. cornuta*	1962
I. integra	*I. leucoclada*	1962
I. integra	*I. pernyi*	1960
I. leucoclada	*I. integra*	1962
I. leucoclada	*I. pernyi*	1960
I. myrtifolia	*I. opaca*	1956
I. opaca	*I. cassine*	1960
I. opaca	*I. aquifolium*	1956
I. pernyi	*I. aquifolium*	1962
I. pernyi	*I. integra*	1962
I. pernyi	*I. latifolia*	1962
I. pernyi	*I. perado*	1962
I. rugosa	*I. integra*	1957
I. serrata	*I. verticillata*	1963
I. sugeroki	*I. coriacea*	1962
I. sugeroki	*I. crenata*	1966
I. vomitoria	*I. cornuta*	1960
I. yunnanensis	*I. crenata*	1964
I. yunnanensis	*I. sugeroki*	1960

Taming Wild Penstemons

*Glenn Viehmeyer**

It is an old story; it began when a caveman planted a wildling outside the entrance to his cave. It will continue as long as man reaches out for something new and different; as long as man is man. This particular part of the story tells how a dedicated group of people, mostly amateurs, have chosen to bring into the garden species of penstemons. These wild, recalcitrant, beautiful natives are, for the most part, unhappy and short-lived in gardens.

The penstemons, near relatives of the snapdragons, are indigenous to North America and number hundreds of species and subspecies; thousands of geographical races have been described. Members of the genus *Penstemon* range from Alaska to Central America; from alpine meadows to deserts and on down to the sea. Some choose the precarious habitat of cliff faces where their roots drive into crevices in living rock, and the plants hang between heaven and earth. Penstemons are, perhaps, among the showiest of all North American wild flowers.

Unfortunately, most species of penstemon fit into narrow ecological niches. They do poorly under cultivation. They fall victim to diseases as garden culture brings them into soft, susceptible growth. Penstemons are specialists, uncompromising in their requirements of soil and climate.

This is where the plant breeder steps in; today we know about cytology and genetics, about inheritance in hybrid populations. We can, in the laboratory, telescope evolutionary time and create new life forms that in nature would take millenia to come about.

Species of many living organisms remain relatively static because of something geneticists call "reproductive isolating mechanisms".Such mechanisms prevent stable species from hybridizing. This preserves the integrity of the species. There are two classes of mechanisms that account for reproductive isolation: internal and external. Internal reproductive isolation mechanisms are part of the chromosomal-cytological complex; external mechanisms may be functions of time, space or morphology. In fact, this is over-simplification; whether internal or external, each "mechanism" actually is a group of limiting factors.

When two species of a genus share the same habitat, growing side by side and blooming at the same time, pollinators will carry pollen from one species to the other. Unless internal mechanisms prevent it, hybridization will occur. If hybridization occurs with appreciable frequency, and if the resulting hybrids are viable and fertile, and if the hybrids of the two species intercross and recross with the parents, the result is a hybrid swarm that combines characters of both species. Natural, interspecific hybridization is very "iffy" business.

Species interfertility usually, but not always, is disadvantageous to participating species. Barriers to intercrossing between species that share a common habitat (sympatric species) often are absolute. On the other hand, species in geographical isolation (allopatric species) may not be separated by internal isolating

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mechanisms. This also holds true for species that bloom at different times (temporal isolation).

Where allopatric species make contact because of range changes or because man brings them together, hybrid swarms may arise. A good example is found in the Penstemon subgenus *Dasanthera,* where eight species, *P. barrettiae, P. cardwellii, P. davidsonii, P. ellipticus, P. fruticosus, P. montanus, P. newberryi,* and *P. rupicola* meet due to overlapping ranges. Hybrid swarms arise from these naturally, and in growers' gardens. On the other hand, penstemon species of the northern and central Rockies and adjacent foothills and plains appear to be in complete reproductive isolation, and produce no hybrid swarms. But many of these species cross readily with *P. barbatus,* from the southern Rocky Mountains and the Colorado Plateau. For example, *P. strictus* is reproductively isolated from *P. glaber,* but both will cross with *P. barbatus*. Also, the resulting hybrids will cross with either *P. strictus* or *P. glaber*. Reproductive isolating mechanisms, then, that prevent direct hybridization can be circumvented by introducing an allopatric species that carries germ plasm across the "unbridgable gap" that separates two species in nature.

This intermediate parent concept enables a breeder to go round the barrier to hybridization. The technique introduces, sometimes, unwanted germ plasm into the resulting hybrid population. Still, this unwanted genic material can be reduced or eliminated via the backcross route.

The following data outline is presented to assist amateur plant breeders with a program of interspecific hybridization. The assumptions presented are based on empirical observations and on the actual production of a rather large series of hybrids that combine incompatible germ plasms via the intermediary route.

(1) Geneticists generally agree that an internal reproductive isolating mechanism is the result of an accumulation of many small mutations over long periods of time. Further, it is assumed that these mutations act in unison to produce an end effect of incompatibility between species.

(2) Assume that all these accumulated mutations have the effect of a chain that ties the gene material of a species into an integral bundle; further, assume that each member of the reproductively isolated pair has its specificity insured in this manner. As long as these chains of isolating genes are intact, they are functional; but if parts of the chains of isolating genes are lost through crosses to a third species, the isolating mechanism becomes nonfunctional.

(3) From the above statements, we may conclude that reproductive isolating mechanisms are not destroyed but merely inactivated. There is some indication that in certain, individual, hybrids they may be reconstituted.

(4) With each subsequent generation following the initial intermediary cross, the "chain" of reproductive isolation undergoes further fragmentation, making possible additional recombinations. Even so, isolation mechanisms may not be completely blocked, but may persist in varying degree in indiviual hybrids.

(5) Fertility of first generation (F_1) hybrids ranges from near zero to about fifty per cent. Fertility increases in the F_2 generation and in subsequent generations may be comparable with that of parental species.

(6) Within a population of segregating generations of hybrids, whole classes of expected segregates may fail to appear. The reasons for such failure are unclear, but we surmise that certain combinations of germ plasm are not viable. This assumption is supported by the observation that the degree of variability in a population appears to correlate to the fertility level of the seed parent.

(7) Interspecific hybrids, particularly those combining germ plasms of several species, serve best as intermediary parents between species. In such multi-species hybrids reproductive isolating mechanisms seem to be lacking or non-functional.

(8) Hybrids of species from differing ecological niches exhibit a wider range of adaptation than either parent. If a subalpine meadow species is crossed with one from the desert, the segregating generations may be expected to produce classes of intermediate hybrids that perform well in econiches to which neither parent is fitted.

The Current Status of Penstemon Breeding

Gardeners are the nemesis of plant breeders working with unfamiliar genera. American gardeners suffer from a "petunia-marigold-zinnia syndrome", a sort of neophobia, or fear of something new and unknown. The breeding outline presented in this article indicates that considerable work has been done with penstemons. Many choice hybrid forms are available to gardeners, but we do not see them in home gardens. It is a problem; people can't want the new, hybrid penstemons unless they see them; they can't see them unless plants or seeds are available, and no nurseryman is going to produce seeds or plants until he knows that a demand exists. But the breeding of highly desirable hybrid penstemon strains continues.

Reviewing *Bulletin of the American Penstemon Society* articles, we find that over 170 strains and clones of penstemons have been named. Sixty-five of these are shrubby, belonging to the subgenus *Dasanthera*. Of the sixty-five, at least thirty-five have been collected or reported from naturally occurring hybrid swarms where ranges of *Dasanthera* species overlap. At least some of these desirable hybrids have been lost, as they were never propagated widely enough to insure their continued existence. This is a real loss to

Large-flowered blossoms on tall spikes characterize the "gloxinoides" penstemons sold as the Sensation strain. This tender race is best grown as an annual.

Variants arising from open pollinated Penstemon glaber. *When inter-fertile penstemon species grow together in a garden, insects affect random pollination. In this case, the blue-lavender parent produced progeny with red and purple-blue flowers.*

From a hybrid swarm of Viehmeyer's North Platte strain come these seedlings. Showy, usually bright pink to scarlet flowers are borne closely spaced on a twenty-inch spike.

An F_1 hybrid of P. unilateralis *x* P. labrosus. *The pink to blue flowers of* P. unilateralis, *all carried on one side of the spike, have served as garden flowers for years. In the garden, this primary cross sometimes is short-lived.*

Resembling the P. cobaea *parent in form, this first generation seedling of* P. cobaea *x* P. triflorus *produces strong pink flowers of great ornamental value in the garden.*

P. lyalli *is a mountain dwelling species which does not adapt to garden conditions. This photo was taken of a wild plant in the upper part of the Swiftcurrent Valley in Glacier National Park.*

These photographs illustrate three groups of penstemons. Three show the progeny of crosses involving several species, typical of the so-called "hybrid swarms;" two illustrate the F_1 progeny of controlled crosses of species; and four illustrate the flower of natural species.

Photographs courtesy of Snyder

P. cobaea *may be lavender, almost pink, or, as this wild, prairie form, white with purple "bee lines." The thumb-sized flowers of this species and some of its hybrid progeny make showy spikes for the perennial garden.*

P. digitalis *is an adaptable, vigorous Middle West species suitable for the sunny perennial border. The selection illustrated here is 'White Queen,' more desirable than the roadside form because the flowers are glistening white.*

Yellow is rare among penstemons, but P. barbatus *var.* flaviflorus *is a strong yellow with a characteristic spike form. Both color and form have been brought into strains of garden penstemons.*

Photograph courtesy of Schooley

gardeners because the hybrid shrubby penstemons are valuable garden ornamentals, especially for the Pacific Northwest.

Hybrids of *P. barbatus* number about thirty clones and at least one seed-grown strain. Of these, five clones have been released by the University of Nebraska North Platte Station. Seedling evaluation continues at the Station, and additional selections will be released from time to time.

Third in numbers of clones and seed-grown strains are the so-called "gloxinoides" hybrids. These are putative hybrids of *P. hartwegii* and *P. cobaea*. Seed catalogs list these as P. gloxinoides, Sensation Hybrids, and under other, less common names. European breeders are releasing many high quality strains and clones of this group; they are suitable for areas with mild winters and long, frostfree periods.

Penstemon hirsutus and P. digitalis are fourth and fifth, respectively, in contribution to the list of named material.

E. Bruce Meyers is working on the shrubby western and the suffruticose species of section *Ericopsis*. His goal is interspecific crosses within that section, and outcrosses with various *Dasanthera* species or hybrids. He also is making interspecific crosses in subsections *Penstemon* and *Procera;* from this may come well adapted mat-forming hybrids suitable for ground cover planting.

Dr. Robert Uhlinger, at the North Platte Station, continues breeding work that I initiated thirty years ago. His goals are greater disease resistance and resistance to lodging under garden conditions.

Though officially retired, I continue to make crosses which inactivate reproductive isolating mechanisms, and so increase genetic diversity in the penstemon gene pool. I am breeding for everblooming garden hybrids, and to purify strains to be grown from seed.

Ralph Bennett and other eastern United States breeders are selecting superior clones and strains of hybrids between eastern *Penstemon* species. Also, these people are working toward better garden forms of the eastern penstemons.

Readers may wish to obtain seeds and plants of the new penstemon strains and clones. They scarcely are available from usual sources, but may be obtained through the seed and plant exchange programs of the American Penstemon Society. Participation in the Penstemon Society seed and plant exchange programs is limited to members. For information, write to: American Penstemon Society, Mrs. Merle Emerson, Box 64, Somersworth, New Hampshire 03878. Dues are $3.50 per year.

The Future Of Penstemon Breeding

Gardeners who wish to grow penstemons have two choices. They can create ecological niches in the garden that faithfully duplicate conditions where penstemon species thrive, and then grow those species. Or they can select hybrid clones and strains from breeders' offerings, and plant these in their borders, beds and wild gardens. There are hybrid penstemons that will thrive in almost every growing zone in the United States; the hybrids are tolerant of widely varying conditions, though, so far as I know, none will do well in a bog garden or in deep shade. As gardeners become aware of the ornamental value of penstemon hybrids, and awareness is growing, a demand will develop. Presently, largely due to the dedication of a few breeders, hybridization goes forward. We can hope that it will expand. Sufficient ground work has been laid down, so that an amateur gardener can step in and help with the job.

Out of the hundreds of penstemon species and thousands of geographical races, probably less than fifty have been used in interspecific crosses. Whole sections of the genus remain unused. With the exception of the promiscuously interbreeding *Dasanthera* species, progress has been greatest following intersectional crosses. For example, the popular "gloxinoides" complex seems to be a result of crosses between *P. hartwegii* of section *Fasciculus* and *P. cobaea* of section *Aurator*. The Flathead Lake complex is based mainly upon germ plasms of *P. barbatus,* section *Elmigera,* and species of section *Habroanthus*. The Fate-seeba complex is based on hybridization between *P. grandiflorus,* section *Anularius* and *P. murrayanus,* section *Peltanthera*. Each section within the genus *Penstemon* contains several to dozens of species; the number of possible crosses is endless. The breeder, working toward predetermined goals, has a vast reserve of gene material at his disposal. It should be possible to produce almost any form of penstemon hybrid that seems desirable.

Breeders today are building disease resistance into hybrid populations. New ways of controlling diseases are being devised, and new chemicals, such as Benomyl, enable a breeder to grow finicky species.

Working with the almost prostrate species, hybridizers today offer broad, flat, mat-form penstemons, mostly shrubby, with astonishingly large, showy flowers. At the same time, other work has produced hybrid strains of upright-growing plants with brilliant, large, bell-shaped blossoms. As breeding work continues, more strains will be refined, making it possible to grow more kinds of penstemons from seed rather than depending on plant division.

The biggest problem facing penstemon breeders is a way to get ornamental strains and clones into the hands of gardeners. Presently, the American Penstemon Society is the sole agency working toward the distribution of a wide selection of penstemons. Now that the genus penstemon has been tamed for garden growing, botanical gardens and public parks should feature displays of the various clones and strains, introducing these fine ornamentals to American gardens.

Control of Phytophthora Root Rot (Wilt) of Rhododendron*

H. A. J. Hoitink

and

*A. F. Schmitthenner***

During the last decade *Phytophthora* root rot has become the most severe disease of rhododendron and certain other evergreens. The disease, referred to as rhododendron wilt, is present in most commercial growing fields in the United States and other parts of the world. White in New Jersey first described conditions favorable for root rot. These include high soil moisture and temperature. Plants on sandy soils, therefore, are generally not affected by root rot while those on poorly drained soils are. Temperatures are high in containers, therefore, drainage is even more important.

Several growers have learned to avoid the disease in heavy field soils by growing plants on hills in rows or by improving drainage. A large percentage of plants grown in this fashion appear healthy when shipped, but die from root rot when exposed to high moisture and temperature conditions. We have found that feeder roots of such plants are infected with *Phytophthora,* but not severe enough to result in obvious foliage symptoms. Rhododendron root rot may have been introduced in this country in this fashion. *Phytophthora* now has spread across the western world on several plant types. The disease is known in parts of Australia and probably occurs in The Orient as well.

The Causal Organisms

Five *Phytophthora* spp. have been associated with the rhododendron root rot complex. Of these, *P. cinnamomi* is the most important. From plants grown in container media with an airspace of approximately twenty per cent and excellent drainage (excess moisture drains out in less than one hour) only airborne *Phytophthora* spp., such as *P. citricola* and *P. cactorum, have been isolated. These can be controlled by regular spray applications with Dithane M-45, Manzate D or Tersan LSR and related compounds. However, P. cinnamomi,* is strictly soil- and water-borne and probably overwinters in decaying roots in soils from which plants have been harvested. It is spread with infested soil on boots, equipment, and in water. Research by Rattink at Boskoop, in The Netherlands, has shown that zoospores may travel into a drainage tile at three foot depth in less than one hour from which they drain into irrigation water. Our field observations substantiate that much of the spread of *Phytophthora* results from movement of zoospores in water. Irrigation water, therefore, should not be taken from wells or streams into which run off water collects.

Phytophthora cinnamomi has a wide host range. It has been isolated from azalea, *Pieris,* heather, *Kalmia, Arctostaphylos, Cryptomeria* juniper, *Taxus* and over 250 rhododendrons from different geographic locations throughout North America. Crop rotation using woody plants, therefore may not reduce the root rot problem. It is not known, however, whether a rotation with herbaceous crops like corn or rye would be effective.

Chemical Control

Chemical control of rhododendron root rot in an established planting is not possible at present. Laboratory and field studies with Dexon and Truban in the United States and The Netherlands failed to demonstrate control of the disease once established. Soil fumigation with methyl bromide does eradicate the fungus.

It is important that the fumigant penetrates to the water table, which should be below the zone into which roots grow. A wet clay layer under peat beds is not

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Rhododendron cultivar showing a diseased branch below healthy foliage.

penetrated by methyl bromide and allows spores to survive. After replanting of poorly-drained, fumigated beds *Phytophthora* zoospores are attracted by root exudates and swim into root zones. Since the natural disease inhibiting soil microflora has been removed by fumigation with methyl bromide, the disease causing fungus can spread more rapidly when it re-enters wet fumigated media. Therefore, peat beds should be well-drained with a water table at least two feet below the surface. This can be accomplished with a layer of coarse sand and gravel below the peat. Walkways should be below the peat level in beds so that water in the walkways does not drain into the root zone.

Effect of pH

In the 1930's, White from New Jersey published that root rot could be reduced by growing rhododendrons in media with a pH of 4.5-5.0. Unfortunately at this soil pH, phosphorus is not sufficiently available for maximum plant growth. The optimum pH for growth varies with conditions but generally is from 5.5-6.5; a range where *Phytophthora* is not inhibited. A lower pH, even though it would minimize Phytophthora root rot losses, would not be a practical means of control for commercial operations.

PROGRAMMED DISEASE PREVENTION

A critical step in the control of diseases of woody plants, in general, is the production of healthy rooted cuttings. The system described here has worked successfully over the past four years. Canadian or German sphagnum peat has provided excellent drainage and has a pH of 3.5-4.1 which checks the development of several pathogens. Aeration was improved by addition of perlite or styrofoam and coarse sand. *Phytophthora* has not been isolated from rooted cuttings produced in such mixtures when the procedures outlined below were followed.

Cuttings were free of soil, insects and disease before they were taken. Stock-plants were sprayed routinely with Sevin or Malathion and Fore, Dithane M-45, Tersan LSR, or Manzate D. Once residues were washed off applications were repeated.

Several cutting dip or soaking procedures are used by growers. Shell soil fungicide 345, Clorox, Captan and LF-10 are examples. Generally, it is not advisable to soak cuttings. Clorox breaks down in a single soak treatment, therefore, a new solution will have to be made for a second treatment. Furthermore, clorox does not kill plant pathogenic bacteria unless concentrations are used that will kill plant tissue. Soaking of cuttings can lead to spread of bacterial plant disease; fireblight is an example. Dry cuttings should be sprayed with water so that hormone powders stick. Even dipping cuttings in water or hormone solutions may cause spread of disease organisms. Soiled cuttings should be avoided but if used, they should be washed in a waterbath that is overflowing continuously.

Propagation

All unpainted woodwork flats, baskets, as well as greenhouse benches were treated with two per cent copper naphthenate. When all the plants were out of the greenhouse the interior was treated with formaldehyde (one part of thirty-seven per cent formaldehyde solution in fifty parts of water). The entire propagating area was sprayed and the greenhouse was kept closed for twenty four hours, then aerated until all odor of formaldehyde was gone.

The entire headhouse was sprayed under benches, painted woodwork, and walkways in the propagating house with a solution of one part LF-10 in 200 parts of water. This treatment was repeated every two weeks throughout the season. LF-10 is not effective in soil or where large quantities of organic matter are present. All propagating tools were soaked (knives, soil levelers, etc.) for ten minutes in a solution of one part of LF-10 in fifty parts of water, (Lehn & Fink Products Corp., 4934 Lewis Avenue, Toledo, Ohio). Propagating beds were filled with a new or sterilized medium. Sphagnum peat with coarse sand and perlite or styrofoam was used. Treatment with air-steam at 160°F. is recommended highly, although expensive.

Experimental research on propagation of hardy rhododendrons under mist showed that the following hormone mixtures when used as a cutting dip resulted in a high percentage of disease-free rooted cuttings:

1) 10% Benlate 50% W.P. or 20% Mertect 60% W.P.
   2% I.B.A. for red-flowered rhododendron or 1% for pinks
   88% Talc for reds or 89% for pinks
   50 p.p.m. boric acid
2) 10% Benlate 50% W.P. or 20% Mertect 60% W.P.
   2% I.B.A. for reds or 1% for pinks
   50% Cut Start #4 (strongest type)
   38% Talc for reds or 39% talc for pinks
   50 p.p.m. boric acid

Hormone mixture (#2) resulted in the formation of a large callus due to the addition of Cut Start, which may or may not be desirable.

Cuttings were watered after "sticking" to assure contact between cuttings and medium. A combination of wetting agent (Aqua-gro or Tergitol) and Dexon 35% W.P. at 10 oz./100 gal. of water plus either 6 oz. of Benlate 50% W.P. or 6 oz. of Mertect 60% W.P. was used at one pint per square foot. The new fungicide Truban has been substituted for Dexon on cuttings and rooted cuttings, however its toxicity to unrooted cuttings is not adequately known. Preliminary data suggests that it is not toxic to cuttings under mist. The wetting agent helps distribute fungicides uniformly in the media. If plants other than rhododendrons are to be grown, experiment with the use of fungicides and wetting agents and treat only a limited number at first to determine whether injury will occur.

Protection During Rooting and Growing Time

All cuttings under mist were sprayed with Captan 50% at 2 lbs./100 gal. of water every two weeks and once a month with Sevin and/or Malathion. Misting was controlled so that plants dried after each application.

After the mist was shut off and cuttings were transplanted, plants were sprayed with Sevin and/or Malathion and a fungicide such as Fore, Tersan LSR, Manzate D or Dithane M-45 (at 2 lbs./100 gal.) every three weeks to keep new growth covered. All wilted or diseased plants and cuttings were removed from the propagating and growing area and placed in a tight container to prevent spread of disease.

Immediately after each potting or transplanting procedure, the Aqua-gro or Tergitol and Dexon at 10 oz. or Truban 30% W.P. at 6 oz./100 gal. of water plus either 6 oz. of Benlate 50% W.P. or 6 oz. of Mertect 60% W.P. was repeated. All ingredients were mixed before application. One pint of the solution was used per square surface area. Containers were placed on gravel not plastic, since plastic allows rapid spread of zoospores from infected containers to surrounding healthy plants.

DISCUSSION

In the preceding section a combination of fungicides and sanitary procedures is described that prevents introduction of known important disease causing agents of rhododendron. In some parts of the country, such as the Pacific Northwest, relatively few disease problems occur other than Phytophthora root rot. This is largely due to the favorable climate for rhododendrons. In these areas a more relaxed fungicide program probably could be used. However, in the Midwest and New England states, low temperatures result in winter injury which leads to *Botryosphaeria* and other infections. In the southeast, *Phomopsis* causes dieback problems. In these areas an integrated fungicide-sanitation program, such as the one presented, is essential.

The most critical factor for successful production of root rot-free rhododendrons is adequate drainage of the soil mix once the procedures outlined in the test are applied.

Preliminary data show that the air volume of container media should be higher than fifteen per cent and preferably twenty per cent. It is important that the air volume does not decrease in containers during the growing season due to breakdown of organic constituents. Root rot has not been encountered in nurseries where growth media contained more than sixty per cent bark. The highest incidence of root rot occurred in container mixes with sawdust as the major constituent, especially if these were placed on plastic. This probably is due to the rapid breakdown of sawdust, as compared to bark, resulting in a decrease of air volume during plant growth. This in turn leads to higher moisture levels and increased root rot problems. Container mixes in which Michigan peat (muck) and sand are used, promotes root rot development, particularly if a fine sand is used. Addition of coarse sphagnum peat does not easily overcome this property of muck and sand mixes. Air volumes of six to eight per cent have been encountered in various mixes of these three ingredients. Mixtures of coarse sphagnum peat, coarse sand, and a finer grade sphagnum peat have an air volume of approximately fifteen per cent, depending on the proportion of the ingredients.

Another important property of media is the time in which added water drains out of a saturated mix. Preliminary data show that a saturated bark mix loses added water in less than one hour if containers are on gravel. All bark types encountered on surveys were suitable for growth. It is not known whether some bark types might be better than others.

Presently rhododendron hybrids and species are being screened for resistance. Differences in resistance have been found. It is expected that detailed data will not be available for two years. In addition, the drainage property of container mixes and its effect on Phytophthora root rot is under investigation.

F_2 GARDENS

a page for the younger gardeners

Boys and Girls

Have you ever watched a seed sprout? Do you know that the root comes out of the seed first, and then the shoot, the part that will become the stem and leaves, appears? Ask Dad for a few garden seeds, or, if he already has planted all of them, perhaps Mother will buy a few small packets at the store. To watch seeds germinate, it helps if the seeds are large ones. Seeds of squash, sunflower and green bean are easy to handle, and they sprout well. Ask for five or six seeds of each kind.

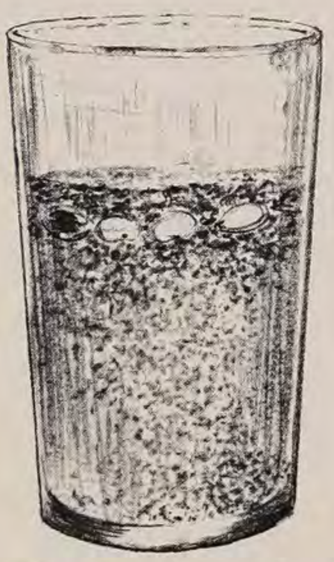
Half fill a clear drinking glass with clean sand. Cover the sand with water, but pour off excess water that stands above the sand. Right against the outside of the glass, press into the sand two squash seeds, two sunflower seeds and two green bean seeds. Add about half an inch of dry sand—no more water. When you have finished planting your seeds, they should be buried, but visible from the side of the glass. Set the glass in a window where no sunlight will strike it. In a few days, the seeds will sprout.

Watch what happens. First, the root breaks out from within the seed, and grows downward. Almost at once, it produces fuzzy root hairs along the side. These tiny organs absorb water from the sand. The water moves up the young root and into the seed. This water helps the top part of the seedling to free itself from the seed coat and grow up above the sand. As your seeds sprout—the correct term for this event is *germination*—carefully break open one each of your reserve dry seeds and study the parts inside the seed coat. Another time, we will study the structure of seeds. This time, we are interested in the parts of the seedling.

Inside each one of these seeds there are two large pieces of tissue, connected with a sort of "hinge". That "hinge" is the thing that will become the root and the shoot of the plant. What, then, are those other parts? The two halves of the bean, the sunflower seed and the squash seed? They are storage organs that contain reserve food to supply energy to the seedling until it becomes self-sustaining. Watch what happens to them.

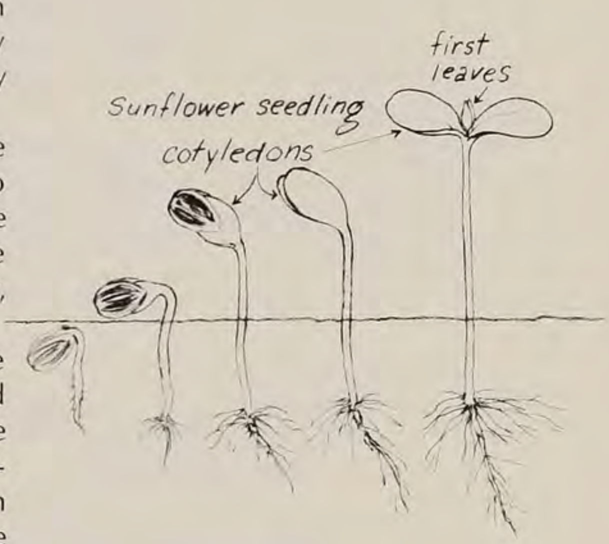
When the shoot of the bean seedling gets above the surface of the sand and the leaves begin to expand, the storage organs—they are called cotyledons, pronounced cot-ih-LEE-donz—gradually shrivel. The food they held is used up, and soon they wither and drop off.

When the shoot of the sunflower seedling gets above ground, the cotyledons grow somewhat larger, and spread out almost like real leaves. For a time, they act like real leaves, too, changing light energy into chemical energy so the weak young shoot can get a good start on its leaves and stem.



press two bean, two sunflower and two squash seeds against the side of a water glass containing damp sand.

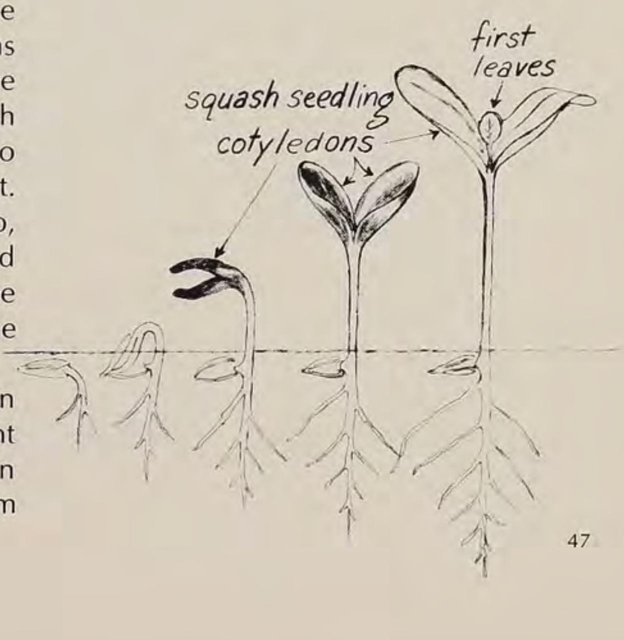
The squash seedling behaves most peculiarly of all. The outer covering of the seed pins the two cotyledons together almost like a paper clip. When the growing cotyledons, held together by the seed coat, get above ground, one side of the seed coat catches on a small peg just below the cotyledons. As the cotyledons swell up with water taken in by the young root, the seed coat is spread open, and soon the cotyledons pop out. If the cotyledons of squash seedlings escape from the seed coat underground, they spread out and cannot ever reach the surface. When they spread out as they should, above ground, they grow and grow. They act almost like real leaves, and gather energy from light to help the young plant grow.



Look at your seedlings and see how each organ does its part. The root comes out first, and picks up water through the root hairs so stored food in the cotyledons can be released as energy to help the shoot grow. The cotyledons sometimes supply stored food until the plant's real leaves take over, and sometimes they not only do that, but, in addition, they act as real leaves for a short while.

The shoot is made up of a stem and leaves. The stem holds the leaves up to the light. The leaves spread out—have you ever noticed that plants growing in a window face their leaves toward the outside light, which is brighter than indoor light—to use light energy in an efficient way. Eventually, when the leaves have manufactured enough food, the stem will also support flowers, and the flowers will make seeds.

To summarize what we have seen, when a seed sprouts, the root comes out first, and gathers water so the rest of the germination process can occur. The cotyledons and shoot grow upward, and the seed coat is discarded. Until true leaves take over, the cotyledons feed the seedling. Does the root do anything else? Yes, it anchors the seedling to the soil. Eventually, it will branch out, spreading through the growing medium (sand, in our glass, but soil, in the garden) to absorb water and minerals for the living tissues of the whole plant. The stem will support the leaves, and, eventually, the flower. Also, water and minerals taken in through the roots will move upward through the stem to the leaves and flowers. Food manufactured by the green leaves will diffuse downward through the stem to nourish the tissues of the roots.



Isn't it wonderful how all the parts of the seedling do their own thing at the right time and in exactly the right way so the entire plant grows properly? Isn't this a good lesson for us? Shouldn't we learn what our duties are at home, in school, and elsewhere, and do them just right, so things proceed in an orderly fashion? ⊗

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