

On the other hand I, like numerous people in this audience, have knowledge of accidents or of cases of health deterioration that took place not only as a result of working with the more dangerous chemicals, but also from working with seemingly harmless materials used in our industry. I have been told by extension people that a number of the older materials including Captan and Benlate are being re-investigated at the present time. I for one consider myself fortunate that the potential danger of chemicals was pointed out to me in a rather simple incident and ever since we have become scrupulously careful when working with chemicals at our nursery.

MANAGEMENT OF SMALL POOLS: VEGETATIVE PROPAGATION OF SELECTED WATER PLANTS¹

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Abstract. The development and maintenance of the aquatic garden at the U.S. National Arboretum, Washington, D.C. is discussed as a general guide for the management of small pools. Information is given on the culture and vegetative propagation of hardy and tropical water-lilies, lotus, and other aquatic plants. Methods for the control of algae and insect pests are also described. The aquatic plants grown in the pool in the 1976 season are listed.

Aquatic displays in parks and gardens in our urban areas are generally open areas of high visibility and, consequently, intense visitor interest. Annual vegetative propagation, seasonal maintenance, and advance planning are necessary to maintain an exciting summer display, year after year. This paper will describe the maintenance of an aquatic garden, the culture and vegetative propagation of hardy and tropical water-lilies, lotus, and various aquatic background plants, and the control of algae and insect pests.

THE POOL — SIZE, CLIMATE AND CONTAINERS

A large display pool at the U.S. National Arboretum, Washington, D.C., partially encompasses the Administration Building. This concrete pool covers approximately 1/3 acre and contains 115,000 gallons of water from 22"-30" deep. Twenty-six

¹ Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

² Plant Propagator

fountain nozzles arranged in a regular pattern at the water surface shoot a constant stream of water 4' to 5' above the surface of the pool, breaking up the glass-like appearance of the water surface. An underwater lighting system provides enough light at night to frame the pool and the auditorium which it surrounds. The water is not artificially heated.

The climate of Washington, D.C. is a temperate, USDA zone 7³ (average annual minimum temperature 0°-10°F). Typically, the last frost of the spring occurs in mid-April and the first frost of the fall occurs in mid- to late October. The display pool may be covered by a thin layer of ice for periods of perhaps a week, several times during the winter months. All of the aquatic plants are grown in square wooden containers, the dimensions of which vary from 20"-26" on a side and 14"-16" in depth. This past summer, there were 50-60 display plants in the pool, showing about 40 different species and forms. Many of our hardy aquatic plants, particularly the hardy water-lilies (*Nymphaea* spp.), remain in the pool throughout the winter and are the basis for our late spring to mid-summer aquatic display.

HARDY WATER-LILIES (*Nymphaea* spp.)

In late April or early May, the hardy water-lily rootstocks are dug up, divided and replanted in boxes with a fresh soil mixture. Young, small "branches" from the older rootstocks should be used — those that have developed and grown the previous year from a bud or growing point on an older rootstock. These young rootstocks, each with a growing point, can be broken or cut from the old rootstock and one or, at the most, two pieces planted in the same tub. Hardy water-lilies grown in containers can be considered short-lived perennials. Old rootstocks are considerably less vigorous and less floriferous than the young rootstocks produced each year from the multitude of growing points on older, second-year rootstocks. In this way, the rootstocks grown in containers quickly develop into a tangled, interconnected mass, physically breaking apart as a result of vigorous growth. I have found that most hardy water-lilies grown in this size container must be divided at least once every 2 years or the vigor of the plant is greatly reduced. Symptoms of overcrowding — mounding up of leaves held above the water surface around the crown of the plant, small flowers, many hidden by the leaves, and a great reduction in the total spread of the leaves over the water — becomes apparent late in the season of the second year of undisturbed growth. Certainly, some hardy water-lilies are more vigorous than others and need more frequent dividing. A replacement of the soil mixture at the time of division means a tremendous in-

³ Plant Hardiness Zone Map. U.S. Dept. Agr. Misc. Publ. 814. Rev. 1965.

crease in the nutrient availability to the young replanted rootstock. The young rootstocks should be planted horizontally or at a slightly oblique angle to allow the growing point to be visible at the soil surface.

All of the aquatic plants are grown in the same soil mixture. The tubs are first filled 1/3 to 1/2 full of rotted, aged elephant manure (or general zoo manure), donated by the National Zoological Park, Smithsonian Institution, Washington, D.C. The remainder of the box, to within 1" of the top, is filled with a loam topsoil. Organic soil amendments such as peat moss and leaf mold should be avoided. The by-products of their decomposition under water can be harmful to fish and plant life. The manure serves as a source of nutrients readily available to the growing plants, but out of contact with the water surface, thereby not contributing to excess algal growth. After planting, a layer of rocks, each the size of a small chicken egg, is spread over the top of the box but not covering or obstructing the growing point or crown of the plant. This presents a nice appearance, helps keep the pool clean, and acts to initially hold the water-lily rootstocks in place until new growth begins and feeder roots develop. It also prevents our resident fish (Nishiki Koi — Fancy Japanese Carp) from clouding the water when they feed and spawn in the plant tubs.

The flowers of hardy water-lilies open in early morning and close in late afternoon, individual blossoms lasting about 3 days. Typical commercial cultivars produce flowers 5" to 8" in diameter. Blooms usually float on the water surface, although some *Nymphaea* cultivars such as 'Sunrise,' a pure yellow, have flowers that rise 2"-4" above the surface on a stiff stalk. Flower color varies from pure white, yellow, to pink and deep rose. For a blue flower, you will have to grow a tropical water-lily. Two hardy water-lily cultivars that are adapted to areas that do not get a full day's complement of direct sun are 'Chromatella' (pure yellow) and 'Commanche' (yellow to rose-apricot at the base of the petals). Other cultivars that have performed well are 'Escarboucle' (deep red petals, white sepals), 'Gonnera' (multiple layers of white petals), 'Rose Arey' (bright pink), 'Attraction' (pink to red petals, white sepals), 'Splendida' (pink), 'Masseniello' (light pink), and a vigorous pygmaea type, 'Joanna Pring' (pink, 2" flower). To overwinter, the hardy water-lily containers are moved to deeper water (8"-10" of water over the tub), below the freezing line, so that the soil surrounding the rootstocks is never frozen.

TROPICAL WATER-LILIES (*Nymphaea* spp.)

Tropical water-lilies have to be propagated anew each year or purchased as young plants; they do not overwinter in the

pool in our climate. In late October, after the first frost, the plants are dug. Beneath the large fleshy crown, small, round, walnut-size tubers occur which can be broken or cut off, cleaned, stored over winter, and sprouted the following spring. Before storing, the tubers are cleaned and dipped in benomyl (1 tbsp/gal) and dried for 1/2 day. They are then stored in a jar with holes punched in the top and layered in a mixture of slightly moist sand and sphagnum. These "stratified" tubers are kept at a temperature of 45° to 50°F until early March.

One method of sprouting a tuber is to plant it in a 5" pot, 2" deep with the growing point up, in a soil mix of 1/2 loam and 1/2 sand. The top 1/2" of the pot is covered with sand and submerged 2" over the top of the pot in water at 75°F. In 2 to 3 weeks, the tuber will sprout and when the leaves become 1 1/2" to 2" in diameter, the sprout and the roots forming on the sprout above the tuber can be pinched off and potted. In this manner, the tuber may sprout two or three times. It is not necessary to pinch off the sprout if only one plant per tuber is desired; simply continue to grow the sprouting tuber. If more than one sprout should form simultaneously on a tuber, one should be removed. Multiple-crowned plants are less vigorous and the flowers tend to be smaller. As the sprouted tubers continue to grow, they should be repotted several times; pot-bound plants have a tendency to go dormant and are slow to recover. Another method of sprouting tropical water-lily tubers is to simply place the tubers on a screen 2" below the water surface and pot up the sprouted tubers when the leaves are about 2" in diameter. Non-viable tubers that have rotted during storage are easily recognized and removed.

The tropical water-lilies are transplanted into tubs in the pool as soon as the water temperature reaches 70°F (early June). The shock of transplanting into cooler water can so stunt the growth that it more than offsets any advantages hoped to be gained by early planting.

Tropical water-lilies in the genus *Nymphaea* can be divided into two groups: day-bloomers and night-bloomers. The day-bloomers have thin-textured light green leaves, occasionally mottled or striped deep purple, and hold their flowers aloft 12"-15" on stiff stalks; flowers open in mid-morning and close at dusk. The leaves of tropical night-bloomers are thicker in texture and deeper green in color to a deep maroon. The flowers, also held aloft on thick stalks, open at dusk and close the next morning between 10 a.m. and noon. The flowers generally last 3 days and the opening and closing of individual flowers depends on the degree of cloud cover on a particular day and the latitude of the pool. Among the day-blooming tropicals, a few will reproduce themselves by forming small plantlets on the

leaves. These are referred to as "viviparous" tropical water-lilies and the offspring as "vivips". On the upper surface of the leaf, at the point where the leaf stem attaches to the floating leaf pad, a small bump will form and in a short time a miniature water-lily develops. As the leaves of the vivip expand and a crown and roots form, the parent leaf begins to decay. These vivips can be potted up when their leaves are 2" in diameter. Or, to encourage undisturbed and faster growth, place a pot of soil under the leaf pad still attached to the parent plant, holding the leaf down on the pot with a few rocks. The vivip sends roots down into the soil and develops into a strong young plant in 3 to 4 weeks. The parent leaf eventually decays and the vivip can then be severed from the parent plant. The water depth over the vivip should be gradually increased from 1" to 4"-5" as the vivip grows. The degree to which a viviparous plant will produce these vivips is dependent on the latitude, being much greater in Florida (where the vivips produce miniature blossoms while still attached to the parent plant) and decreasing as you move north. The cultivar 'Panama Pacific' is strongly viviparous in Washington, D.C.

Both tropical and hardy water-lilies require high soil fertility to bloom freely and consistently. Throughout the growing season, at 2-week intervals, a supplemental fertilizer is applied in tablet form (20-10-5, 5 gram size). These tablets, three per tub, are pushed down into the soil around the crown of the plant. A mixture of hardy and tropical water-lilies blooms from early June through October. The hardy nymphaeas begin blooming in early June and continue through August; the tropical nymphaeas produce their best flowers from July through October.

CONTROL OF ALGAE AND INSECT PESTS

Very few diseases and insect pests are harmful to water-lilies. Nevertheless, aphids are unsightly and can cause minor injury to the leaves and flowers. The best cure is to simply wash the insects off the underside of the foliage and flowers by using a fine spray hose nozzle, allowing the fish to feed on the floating insects. Spraying the foliage with 1/2 strength malathion (50% WP) will also give control without harming plants or fish. Various larvae may feed on water-lily pads, creating a lace-work effect. This can be controlled by sprinkling granules of a larvacide called temephos on the foliage. This does not have any burning effect and provides excellent control for mosquitoes.

Unwanted algal growth is a frequent problem in pools. Fish, if there are enough of them, offer good control. Using soil mixes for planters that do not contain organic matter, or keep

the organic matter out of direct contact with the surface water, also reduces algae. Primarily to control algae, but also to improve appearance and create an illusion of depth, the water in the Arboretum display pool is dyed with a black, soluble, crystalline dye. The dye reduces the penetration of sunlight into the water and thereby limits the algal growth. Numerous chemicals and specific algicides are available (e.g. Algimycin, potassium permanganate, copper sulfate, etc.) but should be used with great care because of the adverse effects an overdose might have on fish and plant life.

LOTUS (*Nelumbo* spp.)

Another outstanding hardy aquatic is the lotus (*Nelumbo* spp.) of ancient legend. Standing 3' to 7' out of the water, the large, round leaves (to 2' in diameter) and cup-shaped flowers (8" to 10" in diameter) are held aloft, singly, on stiff straight stalks. The lotus vegetatively reproduces itself by means of slender, fleshy rootstocks which form a joint every 12"-18" with a tapered growing point at the end. Plants are divided in the early spring of every second year after the last chance of frost. The interconnected rootstocks are dug up, separated, and one or two fleshy joints, each with a growing point, are replanted. The rootstocks are planted horizontally, or at a slightly oblique angle, with the growing tip 1/2"-1" above the soil surface. These exposed growing points can be killed by physical damage as well as by frost if divided too early in the spring. The primary horticultural species, the East Indian lotus, *Nelumbo nucifera*, is native to East Asia. Flower color varies in the single-flowered forms from pure white to deep rose-pink; double-flowered forms with pink flowers are also known. Flowers generally last for 3 days, the petals beginning to fall from the open, third-day flower — exposing the developing many-seeded pod. Another very hardy and often overlooked lotus is the sulfur-yellow flowered American lotus, *Nelumbo lutea*, native to undisturbed water in eastern U.S.A., from New York to Minnesota and south to Florida and Texas. *Nelumbo caspica*, with deep pink flowers, native to the Crimea, is perhaps the only lotus that is not reliably hardy in Washington, D.C. In this case, the rootstocks are dug up in late fall, treated and stored in a manner similar to a tropical water-lily tuber, and replanted after danger of frost is past in spring.

AQUATIC BACKGROUND PLANTS

A superbly edible crop, and one that provides an excellent, grass-like background for showing off other aquatics, is the Chinese water-chestnut (*Eleocharis dulcis*). The brown, bulb-like corms are dug in the fall after the top growth dies back

from frost. They are cleaned and dipped in hot water (130°F) for 2 minutes to decrease rotting, and are stored in slightly moist sand and sphagnum (1:1) in jars or plastic bags at 40°F. In late April, the corms are potted in 5" to 6" pots with the growing tip of the corm at the soil surface. They sprout readily in greenhouse conditions, and in 3-4 weeks are placed in water to the depth of the pots. Young plants, with rush-like foliage 12" high, are transplanted to tubs in the display pool in late May. The young plants should not be completely submerged; 2" to 3" of water over the planting tub throughout the growing season is sufficient.

The list of possible aquatic display plants is limited only by the prevailing climate and one's imagination. The following aquatics, not previously mentioned, were grown this past season and created an interesting educational display as well as the desired ornamental effect under the cultural and climatic conditions described in this paper.

Tropical, non-hardy Nymphaeas: 'Director Moore' (deep blue, TD*), 'Mrs. George Pring' (white, TD), 'Isabelle Pring' (white, TD, not reliably viviparous), 'Rio Rita' (deep pink, TD, not reliably viviparous), 'Pamela' (light blue, TD), 'Pink Platter' (pink, TD), 'Blue Beauty' (light blue, TD), 'Missouri' (creamy white, TN*), 'Emily Grant Hutchings' (deep pink-red, TN), 'Mrs. George C. Hitchcock' (rose-pink, TN).

Additional tropical, non-hardy water-lilies: Giant Water Platters (*Victoria cruziana*, *V. amazonica*, *V.* × 'Longwood Hybrid' [*cruziana* /F/ × *amazonica* /M/]), Indian Gorgon Plant (*Euryale ferox*).

Hardy lotus (*Nelumbo nucifera* cultivars): 'Alba Grandiflora', 'Ohga', 'Pygmaea Rubra', *N.* × 'Maihiren' ('Ohga' × *N. lutea*).

Additional hardy aquatics: Yellow Flag Iris (*Iris pseudoacorus*), Basket Willow (*Salix viminalis*), Hardy Water-Canna (*Thalia dealbata*), Rose-Mallow (*Hibiscus moscheutos*, many cultivars), Zebra Rush (*Scirpus tabernaemontani* 'Zeb-rinus'), Narrow-Leaf Cattail (*Typha angustifolia*).

Additional non-hardy aquatics: Green Taro (*Colocasia esculenta* var. *antiquorum*), Imperial Taro (*C.e.* var. *a.* 'Illustris'), Canna (Canna 'Endeavor', *C.* 'Erebus'), Dwarf Papyrus (*Cyperus papyrus* 'Nanus'), Bur-Head (*Echinodorus palaefolius*).

* TD — Tropical day-bloomer

* TN — Tropical night-bloomer