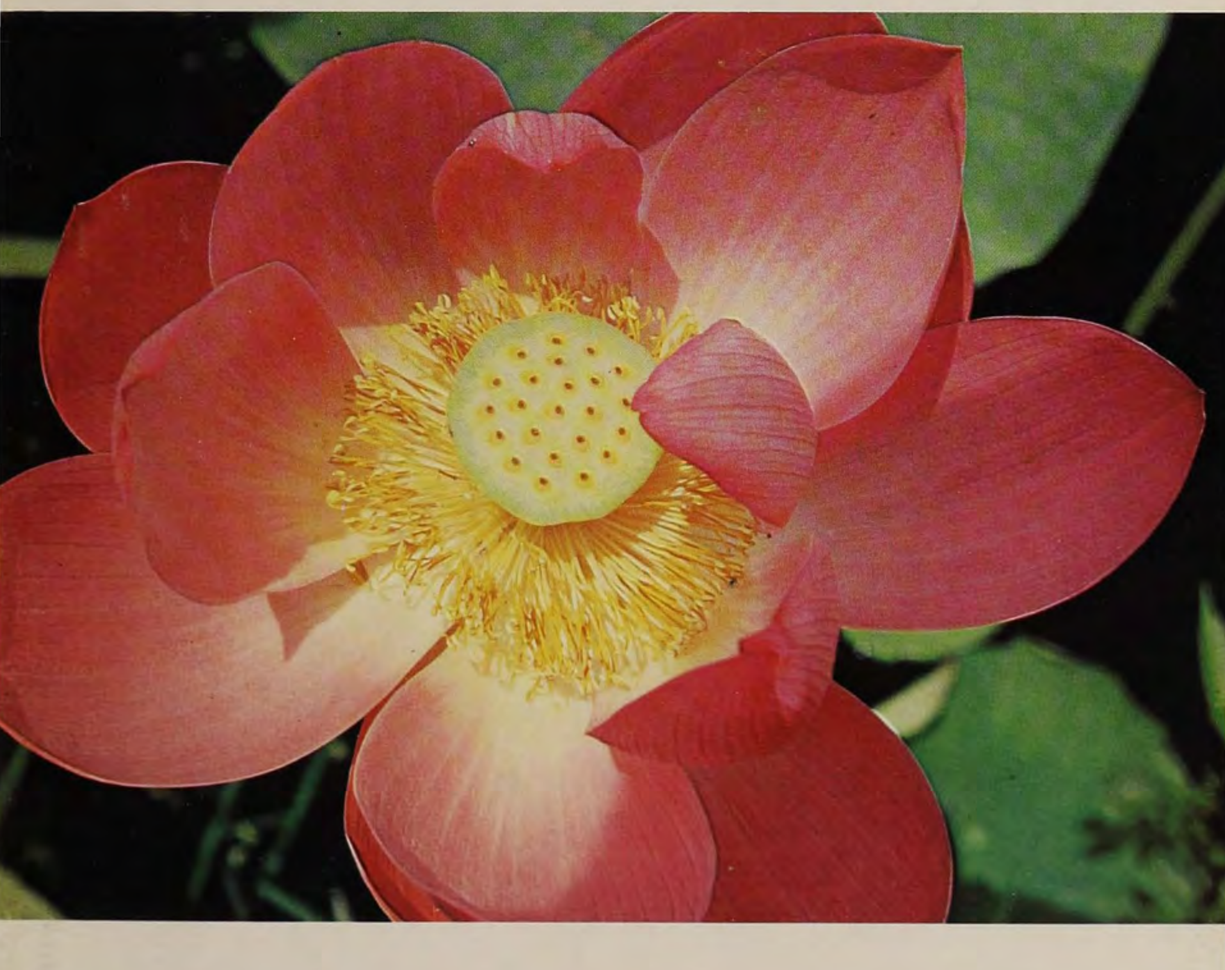
The American HORTICULTURAL Magazine

summer 1971 / *volume 50* / *number 3*

50th Anniversary Edition



Journal of the American Horticultural Society, Inc.

901 NORTH WASHINGTON STREET, ALEXANDRIA, VIRGINIA 22314

For United Horticulture . . .

The particular objects and business of the American Horticultural Society are to promote and encourage national interest in scientific research and education in horticulture in all of its branches.

THE AMERICAN HORTICULTURAL MAGAZINE is the official publication of The American Horticultural Society and is issued during the Winter, Spring, Summer, and Fall quarters. The magazine is included as a benefit of membership in The American Horticultural Society, individual membership dues being $15.00 a year.

THE AMERICAN HORTICULTURAL MAGAZINE is devoted to the dissemination of knowledge in the science and art of growing ornamental plants, fruits, vegetables, and related subjects. Original papers which increase knowledge of plant materials of economic and aesthetic importance are invited. For manuscript specifications, please address the chairman of the Editorial Committee.

Second class postage paid at Baltimore, Maryland and at additional mailing offices. Published at 3110 Elm Ave., Baltimore, Md. 21211.

The opinions expressed in the articles which appear in *The American Horticultural Magazine* are those of the authors and are not necessarily those of the Society. They are presented as contributions to contemporary thought.

1970-71 BOARD OF DIRECTORS

MR. VINCENT K. BAILEY, (1971)
1325 Bailey Road
St. Paul, Minnesota 55119

MRS. ERNESTA D. BALLARD, (1973)
Director, Pennsylvania Horticultural Society
325 Walnut Street
Philadelphia, Pennsylvania 19106

DR. HENRY M. CATHEY, (1973)
Leader, Ornamental Investigations
Agricultural Research Service
U.S. Department of Agriculture
Beltsville, Maryland 20705

MRS. ERASTUS CORNING, II, (1972)
Box 431
Albany, New York 12201

DR. RICHARD A. HOWARD, (1973)
Director, Arnold Arboretum of Harvard University
Jamaica Plain, Massachusetts 02130

MR. EDWARD P. HUME, (1971)
Horticulturist
Southern Illinois University
Edwardsville, Illinois 62025

MR. CLARENCE E. LEWIS, (1973)
Professor of Horticulture
Michigan State University
East Lansing, Michigan 48823

DR. FREDERICK G. MEYER, (1971)
Research Botanist in Charge of Herbarium
U. S. National Arboretum
Washington, D. C. 20002

MR. BRIAN O. MULLIGAN, (1971)
Director
University of Washington Arboretum
Seattle, Washington 98105

MR. JOSEPH W. OPPE, (1973)
Director
Arthur Hoyt Scott Foundation
Swarthmore College
Swarthmore, Pennsylvania 19081

MR. JOHN M. PATEK, (1972)
President
Color Data, Incorporated
434 Mount Airy Drive
Rochester, New York 14617

MR. WILLIAM A. P. PULLMAN, (1972)
700 Mayflower Road
Lake Forest, Illinois 60045

DR. LEON C. SNYDER, (1972)
Head
Department of Horticultural Science
University of Minnesota
St. Paul, Minnesota 55101

DR. NEIL W. STUART, (1971)
Plant Physiologist
Crops Research Division
Agricultural Research Service
U. S. Department of Agriculutre
Beltsville, Maryland 20705

DR. HAROLD B. TUKEY, SR., (1971)
Professor Emeritus
Michigan State University
The Maples
Woodland, Michigan 48897

MR. EARL E. VALLOT, (1972)
Owner-Manager
Grandview Nursery
R. F. D. Box 44
Youngsville, Louisiana 70592

DR. FRED B. WIDMOYER, (1972)
Head, Department of Horticulture
New Mexico State University, Box 530
Las Cruces, New Mexico 88001

MR. ROBERT P. WINTZ, (1973)
Executive Director
Chicago Horticultural Society
116 South Michigan, Room 400
Chicago, Illinois 60602

PAST PRESIDENTS OF THE SOCIETY

Per bylaw provision (1969), past presidents of the Society are members of the Board of Directors—*ex officio* and without vote.

DR. FRED O. COE
(President 1949-1952)
P. O. Box 697
Ross, California 94957

DR. DONOVAN S. CORRELL
(President 1956-1957)
Texas Research Foundation
Renner, Texas 75079

DR. JOHN L. CREECH
(President 1953-1956)
New Crops Research Branch, Plant Industry Station,
U. S. Department of Agriculture
Beltsville, Maryland 20705

MR. FRED C. GALLE
(President 1967-1970)
Director of Horticulture
Callaway Gardens
Pine Mountain, Georgia 31822

DR. DAVID VICTOR LUMSDEN
(President 1942-1947)
3296 Gleneagles Drive
Silver Spring, Maryland 20906

DR. RUSSELL J. SEIBERT
(President 1963-1965)
Director, Longwood Gardens
Kennett Square, Pennsylvania 19348

DR. HENRY T. SKINNER
(President 1962-1963)
Director, U. S. National Arboretum
Washington, D. C. 20002

MR. JOHN H. WALKER
(President 1965-1967)
Executive Director
The Society of American Florists
901 North Washington Street
Alexandria, Virginia 22314

DR. FREEMAN A. WEISS
(President 1952-1953)
1240 Raymond Way
Charleston, South Carolina 29407

DR. RICHARD P. WHITE
(President 1960-1961)
5367 28th Street N. W.
Washington, D. C. 20015

DR. DONALD WYMAN
(President 1961-62)
51 Ballardvale Road
Andover, Massachusetts 01810

MR. WILBUR H. YOUNGMAN
(President 1947-1948)
12808 Meadowood Drive
Silver Spring, Maryland 20904

In This Issue

SUMMER • 1971
VOLUME 50 • NUMBER 3

Featuring WATER IN HORTICULTURE

Editor, FREDERICK G. MEYER
Managing Editor, O. KEISTER EVANS

FRONT COVER ILLUSTRATION
Nelumbo nucifera

Nelumbo nucifera, the East Indian lotus, has long been admired as one of the most beautiful of plants for the water garden. It will flower in a small tub on a sunny patio or make a grander show at the edge of a lake or pond. (Photo F. G. Meyer)

BACK COVER ILLUSTRATION
Puya raimondii

Largest member of the pineapple family (Bromeliaceae). Mrs. Loto U. White, wife of Doctor White stands in front of a 35-foot specimen at a stone quarry at Comanche, on the La Paz-Arica railroad, 13,500-14,000 feet elevation, 60 miles from La Paz, Bolivia. (Photo O. E. White)

[That Blandy Fellows contributed funds for the cover is evidence of the high regard they have for Doctor and Mrs. White.]

Guest Editorial

Water

I am often asked "What is wrong with my house plant?" and I often answer, "It looks like it is being over-watered." The response to my reply frequently is "It can't be. I almost never water it." Then I can answer, "That's the problem. Not enough water." It is difficult to state accurately whether more plants succumb to over-watering or under-watering, but in either case the factor *water* is involved.

Geneticists have enabled us to have varieties of plants superior to the plants of a decade ago. Plant pathologists and virologists have enabled us to grow many plants free from disease. Fertilizers are improved. Those of us growing plants in greenhouses can have sophisticated control of several environmental factors, such as temperature, carbon dioxide and day length. All these improvements and innovations can be nullified, however, by the person at the end of the hose. The decision-making involved in proper watering is crucial.

I have heard people say, "If water is safe to drink it is satisfactory for plants." I never argued with that axiom, until I lived one year in a western city where the water tasted fine but plants fared very poorly unless another source of water was used. Garden enthusiasts in some parts of the United States take the good quality of their water for granted; garden enthusiasts in other sections of the country know they are doomed to despair unless they make some arrangements for better water.

Pollution is a word that seldom is omitted from newspapers and water pollution is a serious problem. In many instances the plants might thrive even if the water is polluted (this depends on the pollutant), but the water may not be safe to handle or the odor may be too objectionable even to the most ardent gardener. We cannot consider water, without paying heed to the topic of pollution.

Some people do not water their plants until the plants are wilted. This is a rather harsh measuring stick to use to determine time of application of water. With some plants, such as the tomato, potential production is reduced each time the plants wilt. Most plant processes require water, and a temporary lack of water can result in a temporary cessation of the process. Photosynthesis is a plant process that requires very little water directly, but a lack of water to the plant results in a wilted condition. The stomates in the leaves close and carbon dioxide is then limited. Plant growth, flowering, and yield are affected adversely.

One process in which water is directly involved is transpiration, which is the loss of water from the plant, generally through the leaves. Excessive transpiration will cause severe wilting, again with adverse effects on growth and flowering. Plants possess some natural protective mechanisms against water loss, such as a waxy cuticle on the leaves, closed stomates, reduced leaf surface, but these protective mechanisms are of little value when water is really deficient. The plants will be badly injured or even die, if water is not applied and transpiration greatly reduced. Under some field conditions application of water is difficult or improbable and transpiration seldom can be restricted by natural means. One method that has been studied is the application of antitranspirants to shrubbery used in landscape plantings, to plants along freeways, or to other plants of high economic or aesthetic value. It is appropriate that such an article is included in this issue devoted to water.

Scientists claim that 7,000,000,000,000 tons of rain fall on the United States each year. One would think that would be enough water to meet all our needs for plant growth, but the water doesn't all fall when and where we need it. Again, natural methods of inducing rain are improbable, but progress has been made in "rain-making." The article on cloud-seeding brings the reader up-to-date on a very fascinating and important topic. Freedom from drought should be tantamount to freedom from the danger of hunger or even starvation in some countries. Control of rain also would be welcomed by the home gardener who doesn't depend on his garden for his diet, but does get discouraged when a lack of rain makes his hobby a difficult task, at best.

As a horticulturist you should have a keen interest in the many pertinent articles on water contained in this issue of *The American Horticultural Magazine*. Good water, pure water, adequate water—these are characteristics you should expect in the water you use in your home and in your garden. You also have some responsibilities as a practicing horticulturist—you can do your part to avoid unnecessary water pollution, you can do your part to avoid wasteful use of water, and you can give your support to the agencies that are attempting to provide you with better and cleaner and more water.

Good water, pure water, adequate water will help you achieve success with your house plants, success in the greenhouse, and success in the yard.

Roy A. Larson

ROY A. LARSON
Professor
Department of Horticultural Science
North Carolina State University
Raleigh, North Carolina 27607

Water Needs Of Trees

THEODORE T. KOZLOWSKI*

Dr. Kozlowski provides background information on the water requirements of trees as a basis for better growth and management of these plants in home gardens. He is an international authority on the water relations of trees and has written a number of books on the subject.

It cannot be emphasized too strongly that water deficits of recently transplanted trees are infinitely more serious than those which develop periodically in well-rooted trees. Trees which are uprooted and moved with bare roots, or even with a root ball of soil, undergo a massive physiological shock because their capacity for water absorption is greatly diminished while transpiration demands continue.

Transplants lose water faster than they absorb it. Many small absorbing roots are lost and the previously well-established contact of the whole root system to a large volume of water-supplying soil is greatly disrupted. This is the reason for pruning back top growth to compensate for root loss in transplanted trees.

The chances of losing a tree are much greater if it is moved with bare roots than with a root ball of soil. Nevertheless, the assumption is too often made that a "B and B" (balled and burlapped) tree is in no danger of desiccation after planting. This is not true.

The capacity of a transplanted tree to resume rapid root growth often is critical to survival. Capillary movement of water from wet to dry regions of soil is slow and, unless the soil is charged with water, continuous root extension is necessary for absorption of water to sustain growth.

*Contribution from the College of Agricultural and Life Sciences
Department of Forestry
University of Wisconsin
Madison, Wisconsin 53706

The transplanter should be constantly aware of one central consideration—that anything he does to promote high absorption of water or reduce transpiration, or both, is useful in improving chances for successful transplanting. Extreme care should be taken that roots do not dry during transplanting. Exposure of bare-rooted trees to drying for even brief moments may have serious effects on reestablishment and survival.

Later survival will depend on the physiological condition of the tree at the time of its exposure, weather during transplanting, efficiency of transplanting, and other factors. If trees are moved with bare roots they should be kept immersed in water or the roots may be packed in moist sphagnum, peat moss, straw or sawdust and wrapped in plastic or burlap. Water loss can also be controlled by various commercial antitranspirants (antidesiccants or wiltproofing materials) applied as leaf dips or sprays, before or after transplanting. (See article on antitranspirants P. 110.)

Deciduous trees are best planted in the autumn after the leaves fall and before the soil is frozen or in early spring after the soil thaws and before the buds open. The danger of losing trees from desiccation increases rapidly as transplanting is postponed into summer because leaf expansion and high temperatures accelerate water loss.

The decreased absorbing capacity of root systems of transplants can be compensated for by decreasing transpiration capacity. Pruning of 15% to 40% of the bud-bearing branches often is beneficial.

Trees up to 10 feet high require less pruning and withstand transplanting better than do larger trees.

The bark of newly transplanted trees generally will benefit from wrapping with crepe paper or burlap to prevent drying and sunscald. Trees with a stem diameter greater than one inch should be braced to prevent swaying which sometimes impedes absorption of water through breaking of the soil-root contact.

Trees should be thoroughly irrigated after planting and regularly thereafter for at least the first few critical years or longer to insure that soil water deficit will not be an added barrier to maintaining a favorable internal water balance. Irrigation to a depth of 15 inches in well drained soils, at approximately weekly intervals is advisable, or less often in tight soils.

Light waterings which wet the surface soil only are often wasted as the water evaporates rapidly from the soil surface and is not absorbed by deep-rooted trees. Watering should not be continued into late autumn in northern areas of the country that are subject to early freezes, since this may prolong growth and not give the tree enough time to harden off.

Water Requirements

Trees are constructed so that they lose tremendous amounts of water mainly by transpiration as water vapor through the stomates (plural) stomate (singular), microscopic-sized pores 10 to 20 microns long usually found on the lower leaf surface in most broadleaved trees.

Stomates are very numerous and generally vary in number in deciduous trees from a few thousand to as many as 100,000 per square centimeter of leaf surface.

Stomatal transpiration occurs in 2 stages involving evaporation of water from wet mesophyll and chlorenchyma cells into intercellular spaces of the leaf and diffusion of water vapor from the intercellular spaces into the outside air (Figs. 1 and 2). Small amounts of water vapor are also lost through the leaf epidermis and through lenticels in the bark of twigs and branches. The stomates generally are open during the day and closed at night.

Whenever tree leaves lose water by transpiration or evaporation, or both, as on a very hot day, the rate of replacement of water by absorption through roots may be lower than the rate of loss from the leaves. This condition leads to dehydration of trees. Water deficits in trees can develop more rapidly than deficiencies of other growth requirements, such as carbohydrates or minerals.

The crown of a tree exposes a vast and efficient evaporating surface which tends to rapidly deplete water from the tree and the soil. For example, an open-grown silver maple (*Acer saccharinum*)

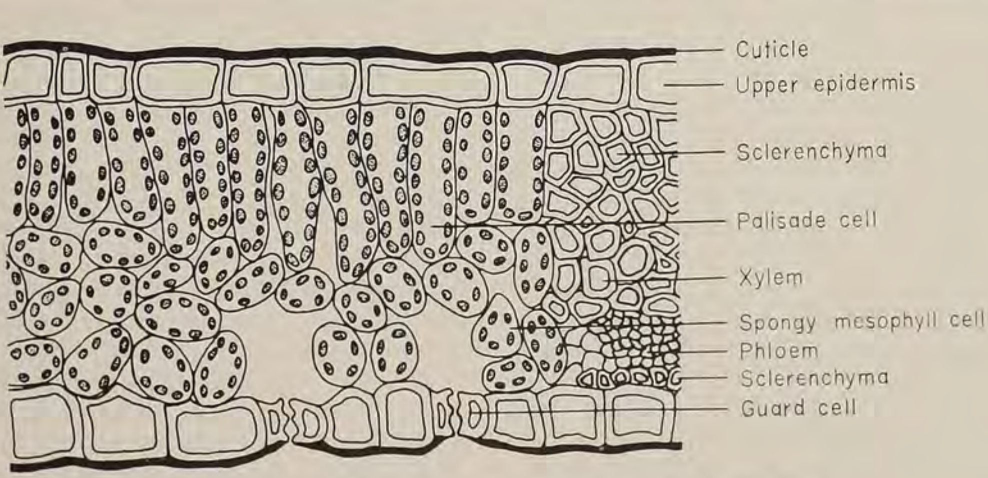


Fig. 1. A deciduous tree—cross section of a leaf blade.

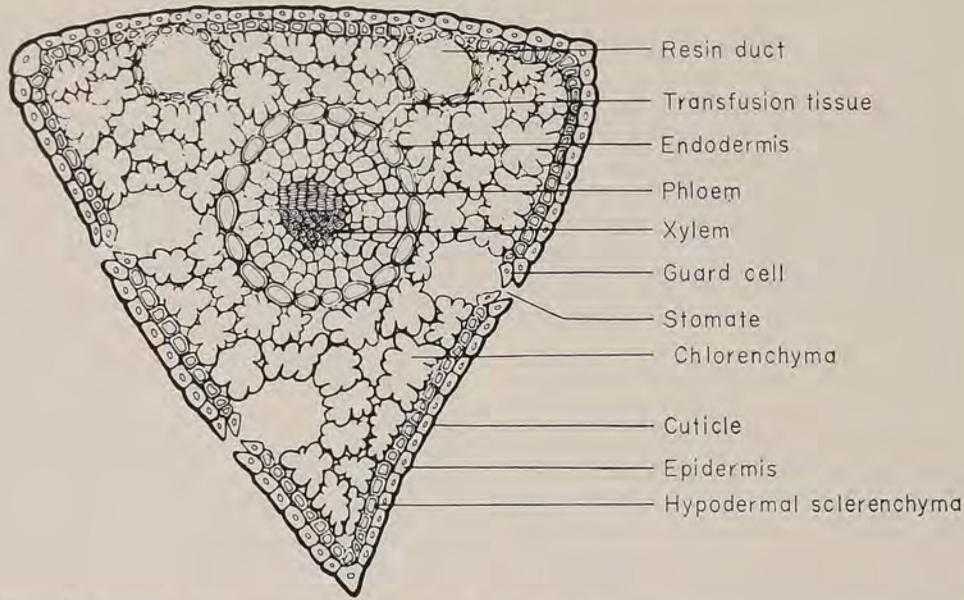


Fig. 2. A pine tree—cross section of a needle.
Figures 1 and 2 show tissue arrangement, intercellular spaces, and stomatal pores through which water vapor is lost. [From Kozlowski (1971a). Growth and Development of trees. Academic Press, New York.]

tree that was 47 feet high had over 177,000 leaves with a combined leaf blade area of a sixth of an acre.

The numbers of leaves vary greatly among trees, but usually all species expose an extensive leaf surface area because leaf numbers and sizes are negatively correlated. Whereas a 21-year-old catalpa tree had 26,000 large leaves, a citrus tree that was only 12 years old had over 90,000 small leaves. A flowering dogwood had more than 50,000 leaves and a hickory tree with about the same stem diameter as the dogwood had less than 5,000 leaves.

Evergreen conifer trees produce many more leaves than deciduous broadleaved trees of comparable age. A 36-year-old white spruce (*Picea glauca*) tree had more than 5 million needles. During its lifetime, a 23-year-old Monterey pine (*Pinus radiata*) tree produced some 14 million needles, but had lost about 8 million so it still carried 6 million of these.

Further insight into the vast surface for evaporational water loss from trees is shown by the observation that an acre of forest trees with a basal area (cross sectional area occupied by stems at ground level) of only 60 sq. ft. carried an aggregate leaf surface area of more than 5 acres.

During a developing drought absorption of water becomes progressively less able to keep up with transpirational losses and therefore net dehydration of trees may be expected over a period of days.

There also is a tendency for trees to dehydrate daily when transpiration is high even if the soil is well charged with water. Hence, water deficits in leaves occur commonly during midday. When the stomates close at night, both absorption of water and loss by transpiration are greatly reduced, but absorption exceeds transpiration. Therefore, trees tend to fill up with water at night.

A tree is sensitive to its water needs and can be dehydrated by excessive transpiration or by slow absorption from dry or cold soils, or both. Transpiration is largely controlled by the above ground environment, primarily light, humidity, temperature, and wind, as well as leaf structure and stomatal opening.

Absorption of water through roots is controlled by the rate of transpiration, size and distribution of roots, and soil factors, such as water supply aeration, temperature, and concentration of the soil solution.

In well irrigated soils, temporary midday water deficits in leaves are not serious because leaves take up water at night after closure of the stomates. However, as soil becomes progressively drier, leaves are less likely to rehydrate at night and decreased growth or injury may follow. If the soil water shortage is not alleviated the tree may die.

Stomatal Closure

Closure of stomates is one of the earliest responses to drought. The stomates close when the water content decreases in the guard cells that surround the stomate pore. As the guard cells lose water and turgidity declines the stomatal pore closes; when the guard cells again absorb water the pore opens and the cells become turgid. The plant is turgid when in a normal healthy state. Turgidity results from water uptake and a higher turgor pressure within cells. Tissues lacking turgidity are sometimes described as flaccid and in a state of wilting.

Dehydration of trees is checked considerably by earlier closure of stomates during each day of a developing drought and by temporary closing of stomates during midday. However, the closing of stomates during a drought may not prevent killing of a tree which loses much water directly through the leaf epidermis by evaporation after stomatal closure has occurred.

Evergreen trees usually undergo more leaf dehydration than deciduous trees before they close their stomates.

Leaves may recover slowly after a severe drought. But this may cause severe damage to stomates which may open slowly or not at all when the tree is finally watered. On a given tree the stomates of shade leaves are more sensitive to water losses than sun leaves. Also the stomates of young leaves tend to close faster than do those of old leaves.

Wilting

As leaves dehydrate and lose water they eventually wilt. Wilting varies in degree and may be classified as: (1) incipient, (2) temporary, or (3) permanent.

Incipient wilting does not cause drooping of leaves. Temporary wilting involves drooping of leaves during the day and recovery from wilting during the night. During a sustained drought plants temporarily wilted may become permanently wilted, a state in which plants do not recover from wilting at night. Recovery from a state of permanent wilting requires rewetting of the soil. Trees which stay in a state of permanent wilting for an extended period often die.

Effect of Drought

Growth in diameter of trees is particularly sensitive to water supply. During dry years trees produce narrow annual rings of wood. During a summer drought, cambium growth either slows or stops altogether, depending on drought severity, and accelerates or begins again following rain or irrigation. Cambium growth in response to dry and wet periods may result in formation of "false" or "multiple rings" of wood in stems. These often have been mistaken for annual rings of wood, leading to incorrect estimates of tree age.

Drought decreases the rate of diameter growth in trees not only in one year but also in later years. A summer drought affects the number of leaf initials which form in new buds for the shoots of the following year, and the consequent reduction in foliage reduces the amount of growth requirements that are translocated downward.

Reproductive Growth

Flowering and fruiting of trees are influenced by the availability of water at any stage during flower bud formation, flowering, pollination, fertilization, embryo growth, or fruit and seed development. However, it is difficult to make broad generalizations on the effects of drought on reproductive growth, partly because timing of the cycle of reproductive growth varies widely.

Flower bud formation often is suppressed by drought but the effect may not be obvious until the following year at flowering time. Sometimes, however, a mild water deficit at a critical time will increase initiation of flower buds by decreasing growth of vegetative tissues. As many have learned, both the size and quality of fruits are improved by an adequate water supply before and during the period of fruit enlargement

Drought Injury

Various tissues and organs of trees often are injured or killed by drought without necessarily killing the tree. Leaf responses to drought include curling, "scorching," marginal browning, early autumn coloration, and premature leaf fall. Leaf drying often causes considerable water injury to evergreens. During winter or early spring days the air may warm and cause considerable transpiration at a time when water cannot be absorbed by roots from cold or frozen soil. This may cause the leaves to dry out and turn brown. If drought continues, the injury to the plant may occur in dieback of twigs and branches.

Following prolonged and severe droughts, stems may become so desiccated that they crack. In some species death of bark in vertical strips and longitudinal cracking may result from water deficits. Drought cracks may or may not heal and, if they do not, they provide openings for invasion by decay fungi and insects.

References

Kozlowski, T. T. 1964. Water Metabolism in Plants. Harper Row, New York.

———. 1968a. Water Deficits and Plant Growth. Vol. I. Development, Control, and Measurement. Academic Press, New York.

———. 1968b. Water Deficits and Plant Growth. Vol. II. Plant Water Consumption and Response. Academic Press, New York.

———. 1971a. Growth and Development of Trees. Vol. I. Seed Germination, Ontogeny, and Shoot Growth. Academic Press, New York.

———. 1971b. Growth and Development of Trees. Vol. II. Cambial Growth, Root Growth, and Reproductive Growth. Academic Press, New York.

Kramer, P. J. 1969. Plant and Soil Water Relationships: A Modern Synthesis. McGraw-Hill Book Co., New York.

Kramer, P. J. and T. T. Kozlowski. 1960. Physiology of Trees. McGraw-Hill Book Co., New York.

Cloud Seeding Brings Precious Water to Parched Land

HERBERT LIEB*

A DC-6 aircraft loaded with flares of silver iodide took off from Miami International Airport during the afternoon of May 7, 1971. Its mission—to search the Florida skies for the right kinds of clouds to seed, in the hope of causing some rain to fall on the parched ground below.

The plane, one of four belonging to the Research Flight Facility of the National Oceanic and Atmospheric Administration, carried a team of weather scientists headed by Dr. William Woodley.

Several hours earlier, Dr. Woodley had taken a hard look at a special "model" of the Florida atmosphere prepared with the aid of a high-speed computer. The model, based on weather soundings made in the early morning, gives a clue to the structure, growth, and behavior of both seeded and unseeded cumulus clouds later in the day. For the sixth consecutive day, the verdict was the same: "unfavorable for any seeding."

The weather for more than a week had been unseasonably cool and dry in large areas of the southeast. Under normal circumstances, most people would call it ideal. But Floridians, in the grip of the worst drought in the state's history and facing a grim water shortage, could not agree.

The drought was a year old. There had been twelve consecutive months with less than normal rainfall. Lake Okeechobee, the reservoir for most of South Florida's water, was perilously close to its record low of 10.3 feet above sea level. South Florida residents were urged to curtail the use of water. The lack of surface and ground water allowed salt water to creep inland farther than ever before in coastal rivers and canals.

Woodley's project had been under way for five weeks by May 7. Since it began on April 1, nature had provided only six days with clouds suited for the scientific experiment. In spite of the computer's pessimistic outlook, Woodley consulted with forecasters of the National Weather Service and found some signs of moisture moving into the area. He decided to go up and look around. Aboard the aircraft, he scanned the Florida skies for two hours, before spotting a cluster of cumulus clouds about 35 miles west northwest of Coral Gables. The plane made 12 seeding passes, dropping 122 flares of silver iodide into five clouds.

From the windows of NOAA's Experimental Meteorology Laboratory at the University of Miami, the "explosion" of the seeded clouds could be seen. They grew from 20,000 feet to 45,000 feet, individual clouds merging to form larger ones. Heavy showers were plainly visible, and high-powered radar recorded rain falling at the rate of half an inch an hour.

That was "dynamic seeding." It involved massive treatment with silver iodide crystals to increase the buoyancy of cumulus clouds and produce taller, fatter, longer-lived clouds. Larger clouds give off more rain than smaller ones.

In South Florida, the Experimental Meteorology Laboratory's statistically controlled scientific experiments on single clouds have demonstrated that, under the right conditions, seeded clouds produce 300-acre feet of water per cloud—seven times the rainfall of unseeded clouds. The same experiments, conduct-

* Deputy Director, Office of Public Affairs, U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), Rockville, Maryland 20852.

ed in 1968 and again in 1970 by Dr. Joanne Simpson, Director of the Laboratory, and by Dr. Woodley, also suggested the possibility that seeding promotes the merger of clouds, increasing their rainfall over limited areas by as much as 10 to 20 times.

It was the success of the 1968 and 1970 Florida-based experiments that led then Governor Claude R. Kirk to ask NOAA to help alleviate the state's water shortage by renewing its cloud-seeding project in the spring of 1971. Florida's present Governor, Rubin Askew, endorsed Kirk's request. Dr. Robert M. White, Administrator of NOAA, acknowledged the request and directed the Experimental Meteorology Laboratory to carry out the experiment from April 1 to May 31.

At the very beginning of the experiment, Dr. Simpson cautioned that it was meteorologically impossible for cloud seeding to "break" a drought. But as the drought and accompanying severe fires worsened to emergency proportions, Dr. Simpson said: "We are morally obliged to make our best efforts available to the community." Dr. Woodley, upon being named Project Director, stated: "Under the most ideal weather conditions, we will be able to help alleviate the water shortage. A good naturally rainy period will be required to fill the reservoirs and break the drought."

During the two-month period, NOAA's aircraft were able to seed clouds on 14 days. A preliminary evaluation showed that on ten of those days there were impressive cloud growths and cloud mergers. Heavy rain fell in the parched Everglades. On April 26 and May 22, substantial rainfall also occurred in the Miami area.

At the request of the State of Florida, the special experiment was extended during the regularly scheduled cumulus seeding research program from June through mid-July under the joint direction of Drs. Simpson and Woodley. A detailed evaluation of the results for the entire period is now under way.

"I am convinced of the success of dynamic cloud seeding under suitable conditions," Dr. Simpson said. "We are greatly heartened by the apparent successes during our 1971 program, but I would like to re-emphasize that dynamic cloud seeding is not optimally or perhaps usefully employed as a tool to combat drought. It should be used in conjunction with a soundly planned water management program. Seeding should be done when conditions are most favorable and the water stored for later use."

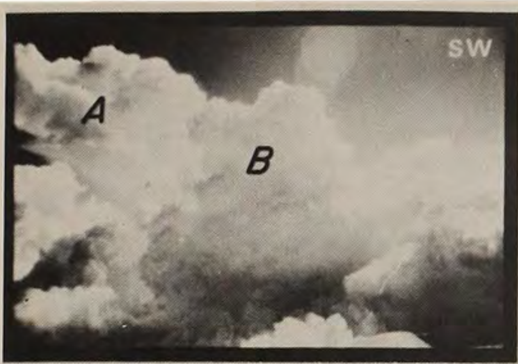
THE MERGER OF TWO CLOUDS AFTER SEEDING-MAY 7, 1971

On May 7, 1971, NOAA's Experimental Meteorology Laboratory conducted a cloud seeding operation about 35 miles west northwest of Miami, Fla. Five clouds were seeded on this date. Two of the clouds, marked **A** and **B** in the photos to the right, reacted spectacularly.

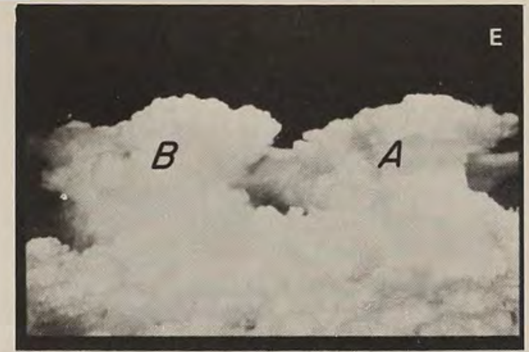
The photos were taken by NOAA's Research Flight Facility's DC-6 flying at 20,000 feet. Camera direction is indicated at the top of the photographs.

The first picture was taken 22 and 2 minutes respectively after the initial seeding. The later pictures show the continued growth and merging of the clouds reaching heights of 45,000 feet and producing heavy precipitation.

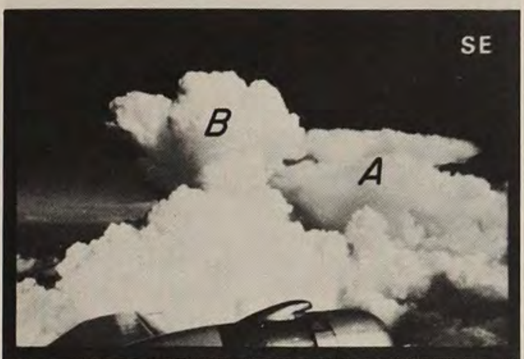
In the last picture the cloud marked "**N**" is a natural, unseeded, thunderstorm that developed 40 miles southwest of the University of Miami. It produced much less precipitation than the merged system **AB**.



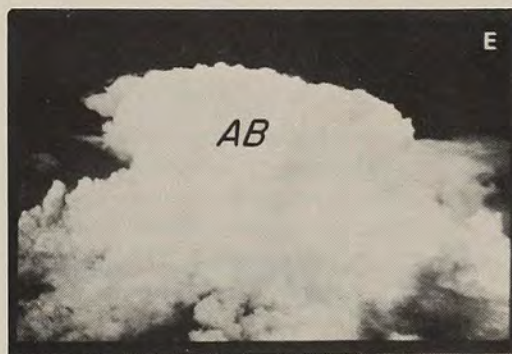
TIME 1544 EST
A. 22 MINUTES AFTER SEEDING
B. 2 MINUTES AFTER SEEDING



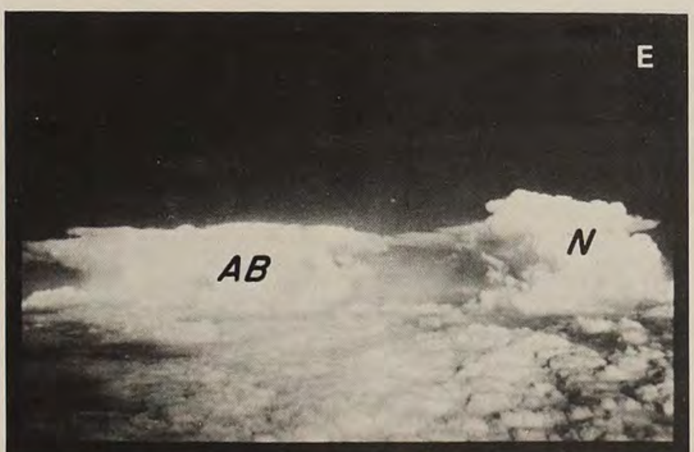
TIME 1625 EST
A. 63 MINUTES AFTER SEEDING
B. 43 MINUTES AFTER SEEDING



TIME 1557 EST
A. 35 MINUTES AFTER SEEDING
B. 15 MINUTES AFTER SEEDING



TIME 1642 EST
A. 80 MINUTES AFTER SEEDING
B. 60 MINUTES AFTER SEEDING



TIME 1742 EST
A. 140 MINUTES AFTER SEEDING
B. 120 MINUTES AFTER SEEDING

Antitranspirants—Effects and Uses in Horticulture

DAVID C. DAVENPORT, KIYOTO URIU, MARY ANN W. FISHER, ROBERT M. HAGAN*

One of the most promising new developments in horticulture is the use of materials on foliage to control water loss of plants. A team at Davis, California reports on recent developments in this new field of antitranspirants.

Antitranspirants when properly used show great potential in ornamental horticulture and pomology. These materials are applied to foliage to reduce water losses by transpiration to the atmosphere.

By slowing water loss from leaves, these "wilt-proofing" materials keep the plant more turgid even though watering is needed less often. There are three types of antitranspirants: (1) compounds that form a film over the stomates; (2) chemicals that prevent complete stomatal opening; and (3) materials that reflect incoming radiation back from the leaves. Since stomates are portals for both loss of water vapor and intake of carbon dioxide, covering the stomates or reducing their openings, curtails water loss and photosynthesis.

The film-forming group of compounds is the focus of this article. These include waxes, wax-oil emulsions, high alcohols, silicones, plastics, latexes, and resins. Ideally, these materials should be cheap, nonpoisonous to the plants, resistant to breakdown, transparent to essential wavelengths of light, and should not interfere with photosynthesis and respiration. However, all known film materials interfere with the passage of carbon dioxide more than with water vapor. This suggests that photosynthesis or the assimilation of carbon dioxide will be reduced more than will transpiration or the loss of water vapor. But this does not always happen, possibly because the foliage is incompletely covered by the film or because there are interactions with environmental factors.

Besides conserving water in the soil and plant, film antitranspirants may also yield other benefits from their protective layer by reducing damage from insect pests, fungi, smog, salt spray, and undesirable water uptake by fruits from rain or sprinklers.

It is not the purpose of this article to compare the several commercial antitranspirants available on the market, but to indicate the effects of and possible uses for antitranspirants.

Applying Antitranspirants

Antitranspirants are normally supplied as liquid concentrates to be diluted in water. They are usually applied as sprays, on a small scale by hand spray gun or aerosol propellant, and on a larger scale by mist blower or field sprayer. Application rates for medium-sized trees may be about 6-8 gallons of diluted spray per tree with a high-volume orchard sprayer, or only 2 gallons per tree with a low-volume mist blower. Plants to be transplanted may be dipped in the material but it will be necessary to protect the roots from the solution so as not to retard water uptake.

Because of the naturally waxy and hairy natures of many leaf surfaces, coverage of foliage by an antitranspirant film is seldom complete, nor is such desirable. Emulsifiers and surfactants (materials that cause wetting) in the solutions improve wetting. Since many plants, particularly fruit trees, have stomates only on the under surface of

* Dr. Davenport, Mrs. Fisher and Dr. Haven are in the Department of Water Science and Engineering; and Dr. Uriu is in the Department of Pomology, all of the University of California, Davis. 95616.

their leaves, spraying those surfaces is imperative.

An antitranspirant material is not equally effective under all conditions. If the plant has wilted because of dry soil and the stomates have closed, an antitranspirant is of little value. Frequent applications of antitranspirant material will be necessary in plants constantly producing new leaves in the growing season, especially at the outer extremities of the plant where transpiration rates are highest. In plants that are not actively producing new leaves one antitranspirant application may have an effective life of one day to several months, depending on the efficiency of the material used.

Toxicity

Antitranspirant materials of the film-forming type may be toxic to plants, if not used in the correct concentration. The concentration of the antitranspirant can be adjusted according to the plant's sensitivity. Thus, RD-9 (product of Mobil Chemical Corporation) at the suggested concentration of 1:5 caused the leaves of several fruit trees to yellow. Yet a concentration of 1:9 was found to be nontoxic to the leaves of apricots and peaches. Olive leaves could tolerate a concentration of 1:7. Leaves may be "suffocated" by a strong concentration of antitranspirant material which is relatively impermeable to carbon dioxide and oxygen.

An antitranspirant will not cause drastic increases in leaf temperature under normal growing conditions. Leaves dissipate heat chiefly by thermal emission, so there is no danger of heat build-up due to the use of antitranspirants. Reducing transpiration with an antitranspirant should not slow mineral supply to leaves enough to retard growth. For example, many xerophytic plants such as cacti transpire at very low rates, but survive without running into problems of lethal plant temperature or mineral starvation.

Growth

Even in well-watered plants, wilting is not uncommon on hot dry days. Antitranspirants can help minimize wilting by ensuring the plant's optimum water requirements in times of high temperature stress in summer. In other words, antitranspirants can help to maintain plant turgidity for normal growth.

Currently available antitranspirant films reduce carbon dioxide intake. Hence, if growth increases are desired, the antitranspirant should be applied at a stage of plant development when growth is more dependent on cell expansion than on photosynthesis. This is illustrated in the following section by data on fruit growth.

Uses in Horticulture

Initial studies on the effects of antitranspirants show promising results. Problems such as long term effects on perennial plants and regulatory standards by the Environmental Protection Agency (EPA) have as yet to be worked out. Experiments have shown some of the potential uses for antitranspirants but, at this stage, are offered as suggestions only.

Fruit trees: A large farming concern in Southern California recently found it necessary to transplant 1,000 seven-year-old citrus trees. The digging in such an operation results in severe root pruning, reducing the trees' chances of survival. Some of the trees were sprayed with an antitranspirant and some were not. Initial measurements showed that sprayed transplanted trees were more turgid than unsprayed trees.

Various experiments show that antitranspirant sprays improve the water balance, (difference between root uptake and transpiration) of fruit trees. Despite the reductions in photosynthesis, this condition may increase fruit size, especially if the trees are sprayed shortly before the fruit matures.

In August 1970 a 1:9 concentration of RD-9 was sprayed about 2½ weeks before harvest on 'Halford' peach trees near Yuba City, California. Fruit volume growth increased 30% between

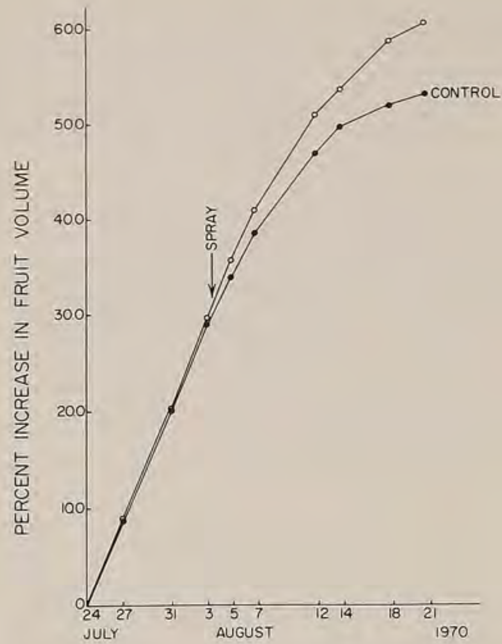


Fig. 1. Increase in growth of 'Halford' peach fruit after spraying the trees with RD-9 antitranspirant.

spray and harvest (Fig. 1). Final fruit volumes were about 5% greater than in fruit from unsprayed trees. Although use of these materials on food crops will require EPA approval, manufacturers do not anticipate major approval problems.

In October, 1969, 'Manzanillo' olive trees near Davis, California, were sprayed with a 1½% concentration of CS-6432 (an experimental antitranspirant from the Chevron Chemical Company). Also included in the experiment was a treatment with simulated rain i.e., trees were sprayed continually during daylight hours with distilled water for 1½ days. The antitranspirant and the distilled water were sprayed on October 13, and both treatments increased fruit diameter over that of unsprayed trees between October 13 and 14.

Natural rainfall on October 14-15 produced rapid fruit growth in all of the trees, but after the clouds cleared, on October 16, fruit size was less on trees not treated with CS-6432. Thus, rainfall enhanced fruit growth only temporarily, whereas the antitranspirant had a more lasting effect, giving a final fruit volume greater by about 13%. Removal of the antitranspirant film from the fruit appears possible during the lye and water processing, but this requires further investigation.

Cherry Cracking: Rainfall during the later stages of cherry ripening causes the fruit to crack, resulting in crop losses of up to 50%. Laboratory tests have shown that water absorption by fruit, which is the cause of cracking, was greatly reduced by an antitranspirant film. The incidence of split fruit was reduced by an antitranspirant wax in preliminary orchard studies.

Ornamental Horticulture

Oleander (*Nerium oleander*): The California State Division of Highways spends about three million dollars annually for irrigating ornamental plantings along California highways. Costs projected for future years are much higher. Watering operations are hazardous along crowded freeways. Any reduction of irrigation costs for the 1,000 miles of oleander plantings along California highways would be of great significance.

Preliminary pot studies with oleanders showed that a film antitranspirant reduced transpiration by about 35%. Water savings were greater if the antitranspirant was applied soon after irrigation instead of when the soil had partially dried out. The effect of retarding transpiration from potted oleanders is illustrated in Figure 2. Field experiments on oleander plantings, both on the freeway and on the Davis experimental farm, suggested that antitranspirants could delay irrigations by two to three weeks.

Since antitranspirants also reduce photosynthesis, it was thought that plant growth of oleanders would be reduced. This would be desirable in highway plantings where excessive growth is usually not wanted. However, the antitranspirant increased shoot elongation by increasing plant turgidity. Mixing the growth retardant Alar (5,000 ppm) with the antiranspirant spray, reduced the shoot growth rates, although reduction

Fig. 2. Effect of reducing transpiration of oleander plants. Initially, both pots began with the same amount of soil water. Five days later the untreated plant (left) was wilting, while the antitranspirant-treated plant (right) remained turgid.

in internode length was not as severe as from Alar alone.

Cut flowers: Experiments on commercially harvested and shipped 'Forever Yours' red roses showed that antitranspirant-treated cut flowers in a vase, lost less water than untreated ones. The buds opened equally well in both treatments. In fully opened flowers, the petals were firmer on the treated stems and did not drop as soon as those from untreated stems. For extending the keeping quality of roses, none of the antitranspirants tested were as effective as a floral preservative.

Bedding plants: Another area of interest to gardeners is the transplanting in the spring. Preliminary trials with "pony" packs of zinnias, petunias, marigolds, and tomatoes indicated that the antitranspirants currently available do not adhere to the foliage well enough to give reliable coverage. However, this problem should be solvable as products are improved. Until then, no specific recommendation is given for using an antitranspirant for this purpose. This does not mean that treatment will not work should one feel like trying a product. It does mean that chances for success will improve as products are perfected. One should look to present antitranspirants as a possible enhancement of sound horticultural practices, never as a substitute.

There are almost limitless possible uses for antitranspirants in ornamental horticulture. Among ideas to be explored would be to develop (1) a product to spray on the lawn so it will not require watering while the homeowner is away; 2) a product which could be used on house plants for the same purpose; (3) truly effective materials for transplanting all kinds of plants, from seedlings to specimen trees; (4) products for helping increase the size of home-grown fruits and vegetables; (5) materials to help grow plants with high water requirements in areas which tend to be too dry for all or part of the year.

References

Albrigo, L. G. and G. E. Brown. 1970. Orange peel topography as affected by a preharvest plastic spray. *Hort. Science* 5:470-472.

Davenport, D. C., R. M. Hagan, and P. E. Martin. 1969. Antitranspirants . . . uses and effects on plant life. *Calif. Agric.* 23:14-16.

Davenport, D. C. and R. M. Hagan. 1970. Antitranspirants. 1970. McGraw Hill Yearbook of Science and Technology: 113-115.

DeRoo, H. C. and R. E. Moore. 1970. Keeping Christmas trees fresh longer in the home. *Amer. Christmas Tree Journal* 14:23-26.

Emerson, J. L. and A. C. Hildreth. 1933. Preliminary report on reducing transpiration on transplanted evergreens. *Science* 77:433-443.

Fieldhouse, D. J., J. C. Ryder, and E. L. Ratledge. 1966. A wax base transpiration suppressant for use on tomato and pepper transplants. *Trans. Peninsula Hort. Soc.* 56:23-28.

Gale, J. and Poljakoff-Mayber. 1962. Prophylactic effect of a plant antitranspirant. *Phytopath.* 52:715-717.

Gale, J., Poljakoff-Mayber, A., I. Nir, and I. Kahane. 1964. Preliminary trials of the application of antitranspirants under field conditions to vines and bananas. *Aust. J. Agric. Res.* 15:929-936.

Gale, J. and R. M. Hagan. 1966. Plant antitranspirants. *Ann. Rev. Plant Physiol.* 17:269-282.

Malcolm, C. V. 1967. Reducing salt damage from sprinkler irrigation. *Calif. Citrog.* 52:122, 124-125.

Waggoner, P. E. and J. E. Pallas, Jr. 1968. Saving the water spent by plants. 1968 Yearbook of Agriculture:213-217.

Knowing Your Soil And Its Water Needs

PAUL W. UNGER*

An understanding of the basic needs of plants as to site, light, and water are all important to good gardening. Yet the plague of many a gardener is often the soil, particularly as it effects the amount of water available for plant use. Dr. Unger explains many of the problems of soils in relation to water and offers useful hints that should be helpful to all.

That plants need water is well-known. Water serves as a solvent and carrier for plant nutrients and is essential for cell development and plant growth. Numerous chemical and physical reactions and all biological activities in the soil require water.

Water is present in all soils. The amount present rarely is optimum for best plant growth. Even when optimum, water remains at that level for only a brief period, especially when plants are extracting the water for growth. Thus soils contain too much or too little water most of the time. Plants require adequate drainage; at the same time water is required for good plant growth.

Factors that influence the relationships between water, soils, and plants are discussed under the following main topics: (1) infiltration, (2) retention and storage, (3) percolation and movement, (4) drainage, and (5) erosion.

Infiltration

Water added to soil by rainfall or by irrigation leaves the surface by infiltration (soil properties permitting); water on hard and baked soils may be mostly lost by surface runoff.

Water infiltration and runoff are influenced by soil characteristics, rates and methods of application, amount and nature of vegetation, or other water holding materials such as mulches on the soil surface.

Generally, water application rates on most sloping soils should be relatively low to keep runoff to a minimum and permit maximum infiltration.

Soil texture and the depth to an impermeable, or slowly permeable layer, strongly influence infiltration. Water infiltration into deep sandy soils may exceed 1 inch per hour, whereas in shallow soils overlying slowly permeable layers or soils having a high clay content, infiltration is much less than 1 inch per hour.

Water infiltration rates also are correlated with the amount of water in the soil at the time water is applied. Infiltration into "dry" soils may be high, but if the soil pores are already filled with water from previous rainfall or irrigation, infiltration may be much lower.

Factors that help maintain high infiltration rates of water into any soil are a high organic matter content, good aggregation (binding together of soil particles), and numerous large pores. The channels made by insects and other soil animals and by plant roots also enhance infiltration.

High-intensity rains falling on bare soil may cause surface sealing and low infiltration. Mulches should be used around plants to control runoff and increase water infiltration. Grass clippings and stems and leaves of plants make good temporary mulches; a gravel mulch may be the solution to the surface sealing problem around perennials as well as trees and shrubs.

Retention and Storage

Between waterings, plants must depend on the water retained and stored

* Soil Scientist, U.S. Department of Agriculture, Southwestern Great Plains Research Center, Bushland, Texas 79012.

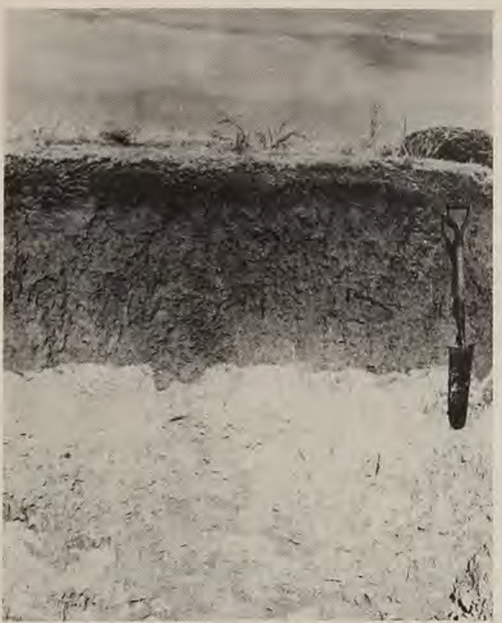


PHOTO USDA SOIL CONSERVATION SERVICE

Fig. 1 Shows a soil profile. Water infiltration, movement, percolation, retention, and drainage varies according to the soil type.

in soil. In saturated soil, part of the water percolates through, provided there is no impermeable layer below the surface. This water percolates into subsurface layers and is largely lost for plant use; what remains in the surface layer is still available to the plant.

Available water varies widely among soil types, but generally is greatest in high silt and clay soils, and lowest for soils having a high sand content. Silt, loam, clay loam, and clay soils retain over 2 inches of plant available water per foot of depth, whereas sandy soils retain less than 1 inch per foot of depth. During hot weather, plants may use 0.3 inch or more water each day. Thus it is readily seen that a sandy soil would require small but frequent water additions, whereas soils containing more silt and clay would require less frequent watering.

The water in soils is retained in the pores or spaces between solid particles. Soil texture affects the porosity. The kind and amount of organic matter also affects soil porosity and some water is retained by the organic matter.

Water is held in soil pores by *adhesive* and *cohesive* forces. By adhesion, very thin films of water surround the individual soil particles (clay, silt, sand). Clay soils because of their small particle size hold more water by adhesion than sandy soils.

Some of the water held by cohesive forces is in the range of water available for plant use. But the water in the fine pores of the soil is held too tightly for plants to remove it. Therefore silt and clay soils with many fine pores contain more unavailable water than sandy soils. A clay soil may contain 2.5 inches of water per foot of depth when the plants begin to wilt whereas a sandy soil may contain less than 1 inch of water when percolation ceases.

Many soils are composed of layers of different textures, which have different water retaining and holding capacities. Such conditions often lead to problems in maintaining a water balance over the entire root zone of a plant.

Percolation and Movement

Percolation is a natural process of well-drained soils. Movement of water in soil is primarily due to gravitational and capillary forces. Percolation occurs after the surface layer has become saturated. Unless an impermeable layer is present (such as clay or rock), water continues to move downward by gravity until all the free water in the larger noncapillary pores is drained from the soil. Free water moves below the plant root zone and into the underground water table or it may escape into ditches or streams.

When plants wilt, capillary water movement has become so slow that the amount moved to the roots can no longer supply the plant's needs. Likewise plants may extract so much water from the root zone that they wilt while adjacent areas in the soil still contain adequate water. Plants cannot obtain water from soil much beyond the reach of their roots. Although root extension does occur, root growth may not be rapid enough to keep the plant supplied with water. Therefore, it is important always to water the root zone area of the plant—not several feet away from it.

Percolation is controlled by the size of the smallest pores through which the water must pass. Sandy soils with large pores result in rapid percolation, while clay soils with small pores result in slow percolation. However, most soils are made up of pores distributed at random throughout the soil.

A common occurrence is for a surface soil containing a large proportion of sand to be underlain by a clay subsoil. In this situation, percolation in the dry surface layer may be rapid at first when cracks are present, but as the subsoil clay becomes wet, it may swell and reduce further percolation. Percolation is also reduced by (1) the clogging of pores with dislodged soil particles and fine organic materials, (2) the blocking of pores by trapped soil air, and (3) the dispersion of soil particles by mineral salts. Ways to help achieve maximum water percolation are by the addition of high organic matter to promote soil aggregation; mulching; and irrigation with water having a low mineral salt content. Percolation is also enhanced by worm holes, insect burrows, and decayed root passages.

Excessive percolation removes nutrients that are essential for plants. This may result in poor plant growth unless fertilizer is applied frequently.

Drainage

Soil drainage in a garden, either too much or too little, is often not an easy matter to overcome. Impermeable layers of rock or dense clay of varying thickness, may restrict the downward movement of water and can impede good plant growth.

Poor drainage conditions often occur on flat, nearly flat, or low areas, where drainage problems may be severe. Poor drainage results in poor aeration and high salt accumulation and poor plant growth. Continued or frequent water saturation adversely affects soil structure, thus reducing infiltration and percolation of water through the soil.

Poor drainage may be overcome by several methods; (1) by drain tiles, (2) by ditches or slopes, and (3) by raised beds or mounds. Drain tiles placed 2 to 6 feet below the soil surface effectively remove excess water. Spacing between tile lines ranges from about 15 feet for very tight soils to several hundred feet for rapidly permeable soils. Suitable outlets must be provided. The outlets should be covered during dry weather to prevent the entrance of animals. When properly installed the value of a tile drain system may be much greater than the initial cost and, the system would be a permanent soil improvement that requires little maintenance. A ditch of the correct size may be the most practical method of draining water from one or a few low areas.

In the home garden planters or raised beds 6 inches to a foot above the soil surface can be very effective for planting shrubs and herbaceous plants. New trees may be planted several inches above the soil line and mulched. To plant high may be the difference between success or failure with a number of plants in areas with poorly drained soils.

Low relatively flat areas are difficult to drain. Such places can be drained best by smoothing the surface and providing a gentle slope toward a natural drainage area.

Erosion

Soil erosion may be the difference between failure or success in your particular gardening situation. Erosion can occur on any soil and can be a serious problem in the average home garden if not controlled. Much valuable top soil can be lost. Erosion causes loss not only of soil nutrients but of valuable organic matter. Lost soil can not be easily retrieved and may bury other plants, clog drains, fill reservoirs, and reduce water infiltration and storage in soil. Erosion also causes unsightly gullies and deterioration of the soil for plant growth.

Rainfall causes splash erosion which is followed by runoff that causes sheet, rill, and gully erosion. Splash erosion begins when raindrops strike the soil surface like miniature bombs to shatter clods and aggregates. Excess rainfall causes water build-up on the soil surface and raindrops continue to cause turbulence in the sheet flow. This helps to keep the small particles in motion and the build-up moves large quantities of soil down slope. The result can be serious erosion depending upon the kind of soil and slope.

Raindrop splash may lift soil particles 2 or 3 feet vertically into the air and move them as much as 5 feet horizontally. Evidences of splash erosion are the soil particles clinging to plants and buildings after a rainstorm. To effectively reduce splash erosion, the soil surface should be completely covered with a mulch material or growing plants.

The destructive effects of erosion depend upon the soil texture (clay, silt, or sand) and the protective mulch that may be present. The nature and slope of the soil also strongly influences erosion by runoff. Sandy soils erode easily because cohesion between individual particles is low. Detached sand particles, however, may not be moved far because they readily settle from the water. Silts and clays, when in a well-aggregated or loosened condition, are highly susceptible to erosion by runoff water and may move great distances after detachment. The muddy waters of streams are attributed primarily to their silt and clay content.

Other effects of rainfall on bare soil surfaces are puddling and sealing of the surface and compaction of the soil. Raindrops cause the soil particles to clog the pores and channels through which water normally enters the soil. Clogging and compaction can virtually waterproof exposed soil surfaces during the first few minutes of a rainstorm and cause serious runoff problems. Surface sealing prevents infiltration and reduces water storage for plant growth. Thus a mulch or plant cover becomes an absolute must to protect soils against surface sealing in some areas of the garden where compaction is a problem.

Soil that normally is bare and highly susceptible to erosion should be mainmained in grasses. Likewise, long rows in a garden should run across the slope rather than up and down the hill. Organic mulches may also be very effective throughout the year in controlling erosion. Materials such as leaf mold, pine bark, pulverized black peat, wood chips, buckwheat hulls, etc. are effective mulches. Also, a gravel mulch can be effective around trees, shrubs, and perennials. To reduce erosion when irrigating, the rate of application should be at a rate lower than the water infiltration rate.

Fig. 2. Bare soil showing a dense crust at the surface, formed when raindrops dispersed the surface soil particles. This resulted in surface sealing and greatly reduced water infiltration.

Know your soil is a good maxim. A knowledge of a few basic principals of soils and water management could be highly useful when applied at the right time.

References

Baver, L. D. 1961. Soil Physics, 3rd edition, pp. 224-303. John Wiley & Sons, Inc., New York.

Black, C. A. 1960. Soil-Plant Relationships. pp. 39-87. John Wiley & Sons, Inc., New York.

Kellogg, C. E. 1941. The Soils That Support Us. pp. 75-89, 239-257. The Macmillan Company, New York.

Lyon, T. L., H. O. Buckman, and N. C. Brady. 1959. The Nature and Properties of Soil. pp. 182-217, 239-273. The Macmillan Company, New York.

Stallings, J. H. 1957. Soil Conservation. pp. 51-70, 510-525. Prentice-Hall, Inc., Englewood Cliffs, N.J.

Stefferud, Alfred (ed.). 1955. Water, The Yearbook of Agriculture. The United States Government Printing Office, Washington, D.C.

Stefferud, Alfred (ed.). 1957. Soil, The Yearbook of Agriculture. pp. 49-60, 378-385. The United States Government Printing Office, Washington, D.C.

Plants in Containers Need Correct Watering

TOM STEVENSON*

Correct watering of plants growing in tubs, pots and other containers is essential to success. If they do not get enough water, they wilt and may die. If they get too much, or if drainage is poor, they soon will be ruined. This is true whether they are growing on patio, balcony, in front of a building, on a window sill, or in the living room of the home.

Soil in containers outdoors will dry out faster than the soil in a regular garden. The soil surface and the sides of the container are all exposed and subject to quick drying. The smaller the container, the more frequent the need for water (and fertilizer). A petunia should have at least a 6-inch pot (6 inches in diameter and 6 inches deep), a cherry tomato a 10-inch pot, a regular tomato plant a 5-gallon container, and a rose bush a 12-inch tub. A bushel basket is an acceptable substitute for the tomato and rose.

If the container is too small, one may have to spend a lot of time keeping an eye on the plants and watering two or three times a day if the soil dries out.

During hot weather the soil dries out rapidly. Sometimes the foliage may lose water faster than the roots can replace it. The plant wilts. High humidity tends to reduce wilting and humidity can be increased by sprinkling the foliage with water.

Some gardeners believe that spraying leaves with water in the hot sun will cause scalding. It isn't true. Studies have shown that the water reduced the temperature of the leaf tissue under it from 8 to 20 degrees.

If wilting is rapid and acute, it may cause almost immediate death of the plant. But more generally plants are subjected to drought over prolonged periods of time. As the plant wilts, the small pores (stomates) in the leaf close, greatly reducing water loss and permitting the plant to survive temporarily. The closed pores, however, limit food production, since photosynthesis requires carbon dioxide which enters the leaf through the pores.

Wilting, therefore, reduces the plant's food supply, reduces cell enlargement and growth, and eventually puts an end to the plant's usefulness.

Use of wooden tubs for containers and tree bark for mulching can lessen the need for watering and reduce wilting. In general, dark-colored surfaces absorb more of the sun's heat than do light-colored surfaces. Black plastic, for example, absorbs much of the sun's energy, while aluminum foil reflects the heat.

Wood and glass are poor conductors of heat. When they are exposed to the sun's radiation, a very thin layer of the surface absorbs most of the energy. Wood is such a poor conductor of heat that very little of the energy striking the surface moves down into it.

Do not depend on a rain, even a heavy one, to provide enough water for container plants growing outdoors, is the advice of M. C. Carbonneau, University of Illinois horticulturist. The foliage of plants will often cause the rain to run off without saturating the soil. Locating containers in protected areas of patios and balconies or under overhangs will cut down on the amount of moisture they receive during a heavy rain.

When the soil becomes dry, apply enough water to moisten the soil throughout the container. Experience should help you determine the correct amount to apply. If the container has drainage holes, apply enough water so that it seeps through the holes. Saucers should be emptied after excess water has drained out of the container.

* Garden columnist *Baltimore News American*, *Washington Post*, and Washington Post/Los Angeles Times News Service.

Containers without drainage holes are difficult to water correctly. Although it is necessary to moisten the entire soil mass, it is very easy to overwater and have water accumulate in the container. When this happens, the container can be tipped on its side to get rid of the surplus water. A trowel or spatula can be used to check the moisture in the bottom half of the container.

As a general rule, it is better to keep containers, expecially those without drainage holes, a little dry rather than too wet.

Sun patterns change throughout the growing season. Containers that need constant watering in the spring and early summer may not be exposed to as much sun during late summer and early fall. On the other hand, as plants grow, they will use more water, increasing the need for watering. Some plants do not wilt as quickly or as obviously as others.

Drainage holes may become stopped up. The accumulation of water and exclusion of oxygen, may cause root rot. The plant wilts during the heat of the day and recovers overnight. This is a symptom of insufficient moisture (the damaged roots cannot provide enough moisture). The tendency is to apply more water and this just makes matters worse.

Root rot is favored by high soil moisture and a high soil temperature of 80° F or more. Soil temperatures are higher in containers than in the garden. In the early stages, there is retarded growth and off-color yellow foliage. Then as the roots die, the top of the plant starts to die.

Watering is the big stumbling block for keeping plants attractive in homes and offices. More house plants probably are ruined by over-watering, under-watering or poor drainage than by all other causes combined.

In many offices and homes people often forget to water their plants and when they do remember, they use too much or too little. If given too much water, the bottom leaves may turn yellow and die. If given too little, the plant wilts. Growth processes slow down, margins of leaves turn brown or black and leaves die progressively up the plant.

A plant can be watered frequently and still die from need of water. The feeder roots are the ones which absorb the moisture and they are mostly at the bottom and sides of the pot. Unless enough water is applied to moisten the outer limits of the soil in the pot, the feeder roots receive none of it.

The resulting short life or unattractiveness of poorly grown plants probably is the main reason so many people have switched to life-like plastic replicas of the more commonly grown tropical foliage plants. It cannot be because plastic plants are inexpensive. The cost of large plastic foliage plants may be three or four times the cost of a living plant the same size. But if the live plant lasts for only a short time, then the cost may be too much for the short time it is serviceable.

Double Potting

There is a fairly easy way to solve the watering problem for foliage plants. It is by double potting. A plant growing in a clay pot is placed inside another pot or tub, one that is at least two inches larger in diameter than the clay pot. The area in between the two is stuffed with moist sphagnum peat or a mixture of sphagnum and perlite. About an inch of the mixture is used to cover the top of the clay pot. In other words, the top of the clay pot will be submerged about an inch below the surface of the sphagnum mixture.

The plant should be thoroughly watered before being double-potted. Water is never again applied to the soil with the plant, but *only* to the mixture surrounding the outside of the pot.

By using this method, the soil around the plant is kept moderately but safely moist for relatively long periods of time, and this encourages slow, healthy growth of most foliage plants used for indoor decorations.

When a new planting is made using the double potting method, the plant may need additional water fairly often during the first few weeks. One can tell by keeping a close daily watch. When drying of the outside mixture is obvious, give it some water. If peat has dried out, it may be difficult to get it wet again.

If the double potting method is not used, there is only one really good way to water house plants. Give them water when they need it and as much as they need and no more. As the surface of the soil dries, it gets lighter in color and water is then needed. When it gets very dry it becomes firm and sometimes cracked because of shrinkage. Most important is that house plants must be checked daily and not once or twice a week for moisture the year round. It doesn't take an expert to follow this system.

Plants in pots can be watered from the top and from the bottom. To water from the bottom, put the pot in a pan of water. Moisture gradually seeps up and reaches the top of the pot. Then remove the pot and allow excess water to drain off for about 10 minutes. Dunking the pot in deep water does the job more quickly. When you water on top pour until water comes out at the bottom of the pot. Wait about 10 minutes for excess water to drain off and then empty the saucer. Do not water again until the soil feels dry to the touch.

A good way to water a plant that has gone too long without water is to immerse the pot completely in a pan of water and keep it there until air bubbles stop appearing. Then take it out and allow excess water to drain off before returning the plant to its saucer.

Use lukewarm water or water that is at room temperature. Cold water will lower the soil temperature and possibly hurt the roots. Hot water also is damaging.

Ordinary tap water is satisfactory for house plants. The chlorine and fluorine sometimes added to city water are not harmful. Rain water and melted snow are good. Do not used softened water.

The danger of light watering once or twice a day is that the top portion of the soil may be moist while the roots at the bottom of the pot may be bone dry.

When in doubt, it is safer to keep the soil slightly dry than soggy wet. Don't let it get so dry that the plant wilts.

While water is necessary to the life of plants, so is oxygen. Water displaces oxygen in the soil. If after watering the plant stands in water that has collected in the saucer, some of the roots may die because of root rot. If the drainage hole in the bottom of the pot becomes clogged, and water accumulates in the bottom of the pot, some of the roots may also die. If the trouble is not corrected quickly, the entire plant may die.

Once a plant has suffered serious injury because of root rot, recovery is a slow and dubious proposition.

Plants in a cool room need less water than those in a warm, dry situation. The more light they get, the more water they need. Plants use more water on clear sunny days than on cloudy days. As a general rule, plants in bloom need more water than those without flowers. If they get an abundance of sunlight, plants may need to be watered twice a day. This is particularly true of azaleas, poinsettias, gardenias, and citrus plants with flowers and fruit.

Get the Most Out of Water

WILBUR H. YOUNGMAN*

Rainfall is highly variable in most parts of the country, seldom following a desirable even flow. Certainly, it seldom provides the continuing needs of plants. This means that often we need to supplement rainfall to keep plants in good condition. Needs vary from garden to garden in an area because summer showers are frequently spotty—one gardener getting more than needed and others little or none. Of course, there are areas where general drought conditions occur. Then too, warnings may be issued saying that supplies of water are dwindling and that all but the most urgent uses must be curtailed to conserve the available supplies.

When such a condition occurs, the gardener must study his watering practices so as to protect his most precious plants. Sprinkling is the easiest method but, of course, it is the most wasteful of water. Soaking the soil by one means or another is much less wasteful. Applying water directly into the root area through a "root-feeder" usually means less loss through evaporation. Mulching is another way to reduce moisture loss through evaporation.

First, it should be pointed out that many farmers and rural gardeners do not have access to water for lawn and garden. Secondly, it should be noted that careful bed preparation, which includes the incorporation of generous quantities of humus into the soil to act as a moisture reservoir for the roots, can be very helpful. It stores excess moisture from each rainfall and delivers it as needed to the plant roots.

It should also be mentioned that careless watering can do more harm than good. Light sprinkling of the garden does not wet the soil to any appreciable depth, in fact, this encourages the plant roots to grow toward the surface of the soil which leaves the plant more vulnerable to drought in times of scarce rainfall.

Also, overwatering can be injurious to the point where plants suffer. I have seen roses so overwatered that they were showing magnesium deficiency. When plants are overwatered, the roots may be unable to obtain needed air, and in a water-logged soil, the leaves may turn yellow and fall. We must always balance our watering to the rainfall so as not to waste water or overwater our plants. A rain gauge is one means; a coffee can is equally helpful (Fig. 1). Persons of experience who are sharp-eyed can tell from the appearance of the plants whether or not supplemental watering is needed.

There are two other considerations that we might keep in mind should severe drought conditions prevail. First, we should conserve our supply of water for the most important plants. Obviously, trees are first, shrubbery comes second followed by perennials and annuals. Shallow-rooted trees and shrubs are more likely to suffer drought injury than deep-rooted kinds, as for example hemlocks and azaleas. Lawn in most areas, especially the bluegrass and fine-leaved fescue turf may be neglected because

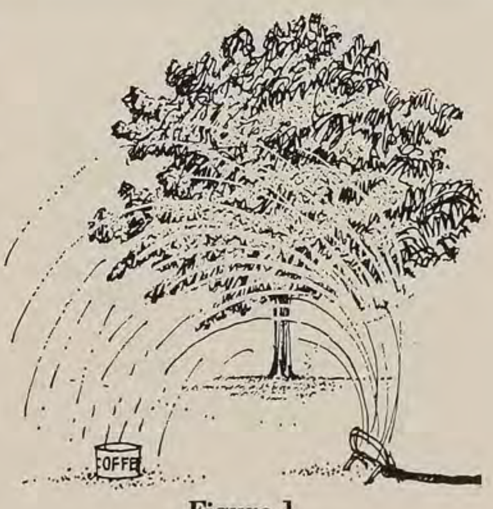


Figure 1

* Garden Editor, *Evening Star,* Washington, D.C.

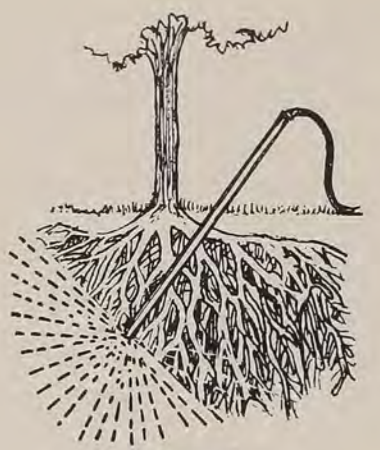


Figure 2

they will go dormant until the fall rains and then revive without serious loss. Of course we can apply water whenever the grass shows signs of wilting and keep it green throughout the summer; but few pay attention to the grass until it begins to brown and has started into a dormancy which watering will not help. In this condition, we should let it become competely dormant in spite of our antipathy to a brown lawn.

Secondly, we should try to make the available water supply go as far as possible. Mention was made of using a root-feeder attachment (Fig. 2) on the hose which will place the water in the root area. Lacking this, we can take a large juice can, punch a few holes in the bottom and set it into the soil near a tree or shrub. When the can is filled, the water will seep into the soil well below

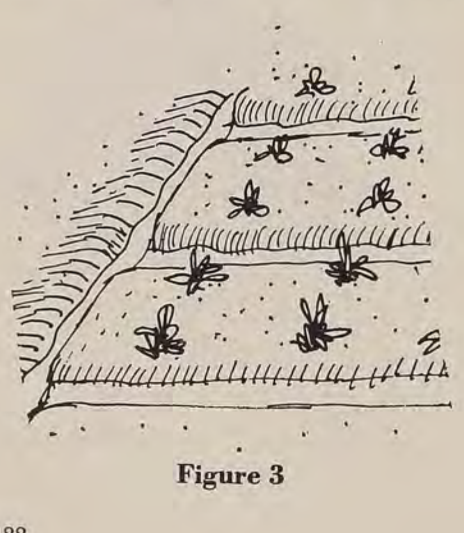


Figure 3

ground level and thus reduce evaporation loss. A clay tile buried vertically in the soil and filled with water, will help to put the water into the root area.

There are problems of watering beds. Where the ground is level, shallow ditches may be made which will carry the water to the plants (Fig. 3). If the ground is sloping, it is possible to carry the water in ditches back and forth so as to reduce rapid flow and permit it to soak into the ground. If this is not practical, we may use either a cotton or a plastic soaker hose which allows a slow application of water to the soil surface. In addition to the above methods, we also have sponge devices that reduce the

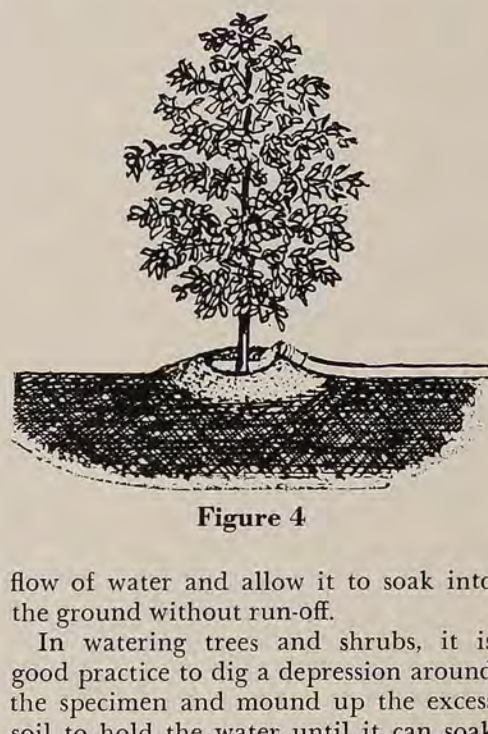


Figure 4

flow of water and allow it to soak into the ground without run-off.

In watering trees and shrubs, it is good practice to dig a depression around the specimen and mound up the excess soil to hold the water until it can soak into the ground (Fig. 4). A more pretentious method is to lay a line of tile in flower beds before planting, at least a foot below soil level. The slope of the tile should carry the water the full length of the bed. At the upper end it can be brought to the surface where water from the hose (or other source) can be poured into it. This insures the water going into the root zone with the minimum loss. However, this system does not work too well in deep sandy soils, nor is it satisfactory in areas of alkaline waters where subsoil drainage has been provided for periodic flooding to remove the excess salts.

Soil conditions must always be considered when planning a watering program. Soils with poor subsurface drainage, especially those that have been compacted by a bulldozer in grading operations, should be watered sparingly and more often than those with normal structure. Sandy soils do not hold water unless they have been improved by the addition of organic matter such as humus, peatmoss, compost, or leafmold, or are underlaid with a tight substrata. Loam soils, such as clay loam and silt loam are much easier to handle than are the sands and heavy clays. Peaty soils are seldom a problem since they hold moisture for a considerable period.

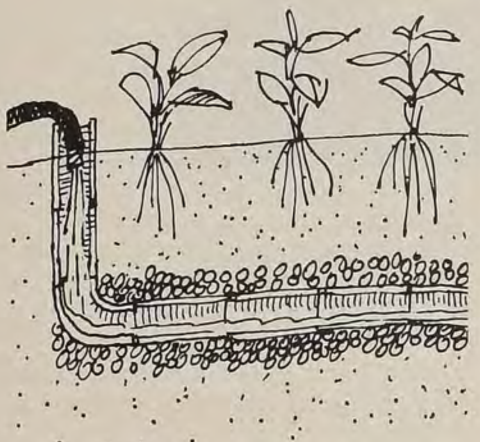


Figure 5

We note that some municipalities that provide "city water" have one good suggestion and that is to do the watering during mid-day when the normal use is at the lowest level. This is a good suggestion because watering at night, while theoretically involving less loss by evaporation, has a possible bad effect—the spread of fungus diseases.

In areas where rainfall is spotty or where periods of summer drought are to be expected or soil conditions cannot be modified, we might give more attention to using those kinds of plants which are noted for their drought resistance. The Nehrlings have provided us with extensive lists of such kinds which should help us plan our gardens to withstand the vagaries of Mother Nature. [Easy Gardening With Drought-Resistant Plants by Arno and Irene Nehrling, Hearthside Press, Inc.] Plants recommended in this book should be on the must list for gardeners in the new suburban areas.

Let us hope that rains come soon. In the meantime, be sure that all trees, shrubs, annuals, and perennials are well mulched so that we will not have to water the hard way. Next year, make certain that every bed is deeply dug and a generous supply of humus is worked into the soil which will hold the excess from one rain until the next one arrives.

PHOTO F. G. MEYER

Water displays at the Generalife, Granada, Spain epitomize the refreshing coolness of water in the garden.

Water as a Decorative Element

HENRY T. SKINNER*

Water is the difference between rhododendrons and a bank of mesquite and cacti, between luscious and mediocre strawberries, or between a velvet lawn and a crabgrass sand patch. But of itself, aesthetically, water can also spell the difference between a restful or tiring, an exciting or a drab landscape.

As a pool or streamlet, as fountain or cascade, water is capable of adding immeasureably to the interest of any garden. It can bring movement, variety, and music. It has a universal appeal borne of its impact upon human emotions.

Quiet pools and ponds bring a sense of peace and placidity. As reflectors of light, their surfaces are reflectors also of objects, the sky, of plant images, and of impressions of the mind.

Sparkling cascades are soothing to listen to, and to watch. Waterfalls suggest playfulness, bring shimmering light patterns and changing music, as shattered rivulets are dashed from rock to rock to dimpling, echoing water-hollow.

Freestanding fountains are unique among all art forms for the varied and varying architecture of the water mass. Light-catching, upswelling, and in constant process of joyous renewal, foun-

* Director, National Arboretum, U.S. Department of Agriculture, Washington, D.C. 20002.

tains have been the inspirers of art, poetry, and music throughout the ages. They provide emotional stimulation to any beholder of average sensibilities. In the atrium or in even the smallest garden, a wall fountain or a tiny pool provides constant interest, coolness, or mini music.

From a philosophical standpoint, the only prerequisite to water's maximum contribution, aesthetically, is that the circumstances of its use be tasteful and in harmony with the garden setting. A natural pond or stream is likely to present few problems, but how many of us can count a blessing of this kind? Our own use of water is most likely to be a manufactured one. If this use is essentially of a formal or architectural nature, few problems will arise, provided that the general concept of the water feature is interesting, good, and in pleasing architectural harmony with the immediate surroundings, of whatever traditional or contemporary style these may chance to be. If, on the other hand, we are seeking a naturalistic effect, in natural surroundings, please let us remember that our product can be killed by the thoughtless introduction of flagrant artificialities!

The use or misuse of rocks may serve as an example.

The edge of a naturalistic pond invites the inclusion of rocks to suggest the presence of a deeper hidden mass which has been partly exposed by weathering and by lapping of the water. A few rocks only may be needed for placing part in and part out of the water, along but one or two portions of the pond's margin. The mistake so frequently made is to entirely surround the pond with stones, flat or evenly irregular like the teeth of some prehistoric monster. A continuous stone border, however naturalistic it is *intended* to be, should seldom if ever be used around a pond or pool of other than formal design. Concrete or plastic liners are concealable by better means than this.

Effective naturalism in the use of water (at which the Japanese are past masters) asks only that the precepts of nature be not too obviously ignored. The pond or stream should fit the scheme in a basically natural way. A waterfall should preferably appear, not like a flight of steps, but as if nature had made it. And, just as a stream will not naturally appear from nowhere at the highest point of a rocky eminence, so will a pool be out of place on a hillside, if there is nothing more than a bank of soil to keep it in position; long ago the water would have cut through the soil to flow downwards and collect only in the lowest discoverable depression. If a stream turns, there should be evident some reason for its turning, a rock ledge or a fallen boulder. If it cascades over an isolated rock, it does so only because it cannot get around that rock by cutting through softer material. An earth embankment to such a waterfall would be detectably unnatural. Principles such as these may, on the surface, seem unimportant, but neglect them and the attempt at the naturalistic use of water will be sadly unconvincing.

Old Faithful aside, the fountain may usually be regarded as a formal expression of water use. It relates to architecture or to architectural settings and thus, with formal pools, becomes easier to install, with less aesthetic risk, by the novice designer gardener. And, of course, forms have changed, even for the fountain, with the flowering of twentieth century art. Bizarre styles have evolved in which varying configurations of dripping and spouting pipes spew water into many sizes and configurations of metal or concrete basins, bowls, and puddles. In almost dramatic advance, technology, moreover, has been brought to bear upon the naturalistic. By selection of a plastic rock pile of the desired height and color, a mountain torrent can now be induced to emerge, by illusion, from the corner post of the patio's louvered fence; and demands upon the installer are minimal. While the inspirational impact of an installation of this kind is of muted quality, the water tries hard, even under these circumstances, and to the discerning viewer an emotional reaction can be virtually guaranteed.

Choosing Among The Hostas

GERTRUDE S. WISTER*

Hostas or plantainlilies, widely known among gardeners as funkias, have long been valued for the interest of their foliage, for their adaptation to shade, their hardiness and ease of culture. It is now more than ten years since an article about hostas by the late Frederic P. Lee, illustrated with excellent drawings and photographs, appeared in this magazine (4). Since that time, interest in them has led to the formation of the American Hosta Society. Many recent importations from Japan and the discovery of attractive sports and chance seedlings by sharp-eyed gardeners have swelled the number of interesting cultivars and species. There has been a limited amount of purposeful hand crossing, and some work with colchicine to induce tetraploidy.

It is in the foliage that hostas present us with the greatest range of variation. In size, there are plants with leaf blades more than a foot long, and a foot wide. At the other end of the scale, there are plants with leaf blades but one inch long, and half an inch wide. There is a range in leaf color from those with glaucous leaves to those that have foliage that is yellow through the whole summer; and, of course, there are the many variegated kinds—those with leaves variously edged, blotched or striped with white, cream, or greenish yellow. Leaves can also be long and slender or rounded, leaf bases can be strongly cordate, or narrow gradually to the petiole. Leaf margins can be wavy or rippled or rather twisted.

Considering the vagaries of the foliage, it is tantalizing to have the flowers of plantainlilies so stable. In color, most of the flowers will be found to fall into the 5 Purple segment on the Nickerson Color Fan. The flowers of some lean slightly to 2.5 Purple, which is a little bluer. Flowers that seem to be pinkish are simply more dilute purple, up to 5 P 8/5, while those flowers that are described as blue are of a more concentrated purple. *Hosta ventricosa,* the "bluest" of the hostas, sometimes called *H. coerulea,* is light purple (5 P 6/7) outside, and moderate purple (5 P 5/9) inside. However, we also find among the plantainlilies some with flowers of purest white, that color striven for but not yet attained through many generations of breeding marigolds and hemerocallis. Yet at least one worker with hostas believes that some day we shall have kinds truly redder or bluer than those we now have.

A Selection Of Hostas

The choice of garden flowers is always a matter of personal taste, and anyone who grows many of a certain group is bound to prefer some to others. Much as I like certain hostas, others strike me as being rather dowdy and lacking in distinction. Your real hosta enthusiast, of course, revels in having one or two hundred kinds, and is always on the lookout for more. He is addicted to trading with other enthusiasts. I, too, am happy to do a little trading but am not averse to discarding those plants that do not seem to be sufficiently interesting to be given room in an area where many other kinds of plants are also grown.

It may be, also, that the differences in climate and soil make my cast-off someone else's treasure, and this applies especially to plants with yellow foliage. I suspect that it may be early hot spells in the Philadelphia area that bring out the green in leaves that would retain their distinctive color longer where it stays cool.

First I have listed fifteen plantainlilies that seem to me to give a good range in aspect and blooming season in my garden. Later on I have added a list of hybrid plantainlilies along with the names of scarce kinds that are still difficult to obtain. The customary single

* 735 Harvard Ave., Swarthmore, Pennsylvania 19081.

quotes are used to indicate established cultivar names; double quotes indicate names in wide use which are of doubtful status, or no status at all beyond that of wide use. Since the nomenclature of hostas is extraordinarily confused, I have also included the names of the botanical authors. Pertinent synonyms are also included.

PHOTO GERTRUDE WISTER

Fig. 1. The fragrant plantainlily, *Hosta plantaginea*.

HOSTA PLANTAGINEA (Lam.) Asch. (Fig. 1), Syn. *Funkia subcordata* Spreng. Fragrant plantainlily or August lily. This has to lead my list. Large leaves, blades about 10 inches long by 5 inches wide, are a shining strong yellow green. In August scapes arise above the two-foot mound of foliage to about 30 inches, each bearing 20 to 30 flowers. These are surpassingly fragrant, pristine white, 5 to 6 inches long (largest of the hostas), opening in the evening. Even large plants do not produce many scapes, but every flower counts. The variety *grandiflora* (Sieb.) A. & G. is said to have more elongated leaves and acute perianth lobes. I think this is the one we have. It is a native of China.

Among the many plantainlilies with white-edged leaves I choose the following trio differing from each other in size.

HOSTA CRISPULA F. Maekawa. (Fig. 2). Syn. *H. fortunei* var. *marginato-alba* L. H. Bailey. There is a fine clone grown in this country under the name of the synonym which is notable for the stately yet graceful posture of the foliage. The tapering, wavy leaves, strongly margined with white, are nearly a foot long by 6 inches wide, on petioles to 14 inches long, making a mound from 18 inches to two feet. The flowers in July, rather pale purple on scapes up to 4 feet, are not its strong point, but it is a superb foliage plant. There are clones of *H. crispula* from reputable European sources that differ in height and time of bloom. The one common in Sweden, described by Hylander, is apparently lower. True *crispula* should have the wavy, tapered leaves and produce an abundance of viable seed (not likely to give white-edged seedlings). The clones *H. fortunei marginato-alba* and one called *H. fortunei obscura albo-marginata* can be differentiated from *H. crispula* by their flat, less tapered leaves and little or no seed.

PHOTO PAUL E. GENEREUX

Fig. 2. *Hosta crispula* is the most stately and graceful of hostas with white-edged leaves.

HOSTA DECORATA L. H. Bailey. Blunt plantainlily. This has been called 'Thomas Hogg', but there are one or more hostas of similar size with white-edged leaves in commerce under that name. *Hosta decorata* is unmistakable. It is of medium size, with white-edged leaf blades about 6 inches long by 4 inches wide, rounded at the apex. The distinctively urn-shaped flowers appear in August on scapes about 24 inches high, giving a well-proportioned plant with the two-foot mound of neat foliage. Copious seed is produced.

PHOTO F. R. WILLIAMS

Fig. 3. Mrs. Williams found the dainty white-flowered *Hosta* 'Louisa' as a chance self-sown seedling in her garden.

HOSTA 'LOUISA' (F. R. Williams). (Fig. 3). This has been listed as F.R.W. #537, *H. minor alba* white edge, and *H. lancifolia albamarginata alba.* The smallest of my trio has leaf blades about 4½ inches long by 1½ inches wide, and makes a mound of about 14 inches. The flaring pure white flowers, freely produced, appear on well-proportioned erect scapes in mid-August. This is a charmer, offering good contrast to its larger relatives. It produces good seed.

HOSTA SIEBOLDIANA (Hook.) Engler. Syn. *H. glauca* (Sieb.) Stearn. This variable species is probably at its most effective in the variety *elegans* Hylander, with its large leaves, sometimes exceeding a foot in length and almost as broad, strongly puckered between the prominent veins. Leaves are blue-gray, especially earlier in the season, from the waxy secretion on the leaf surfaces like the bloom on a plum, which tends to wear off in summer storms. The flowers of this hosta are so faintly tinged purple that they have a grayish look, and they hardly show above the handsome foliage. Still, they are abundantly produced and do add interest in the shade during the latter part of June. Fertile seed is produced in quantities; offspring is rather variable.

HOSTA TARDIFLORA (Irving) Stearn. (Fig. 4). This choice plant is, as far as I know, the last of the hostas to bloom. Its season begins here in mid-September. The light purple flowers open directly above the foot-high mound of moderate olive green. The glossy leaf blades are about 5½ inches long by 2½ inches wide, tapering to the apex, but there are forms that vary in leaf proportions. There may be as many as 50 flowers to a scape, set closely together. Its good proportions, fine dark foliage and pretty flowers make this a true garden jewel.

PHOTO F. R. WILLIAMS

Fig. 4. September brings the delightful light purple flowers of *Hosta tardiflora.*

HOSTA "NAKAIMO" is probably a clone, but is usually listed as a species. It is sterile, or nearly so, and *H. capitata* (Koidz.) Nakai may be one of its parents. It is effective for its large foliage and freely produced attractive flowers. Leaf blades are slightly wavy heart-shaped, about 10 inches long by 6 inches wide, on petioles about twice as long, making a two-foot mound. The many scapes vary from 2 to 4 feet in height. The light purple flowers open in July, with as many as 35 to 40 crowded into the top 5 to 7 inches of the scape. The floral bracts are whitish, tinged pale purple, making the congested cluster of bracts and developing buds very attractive. The scapes lean gently toward the light without sagging in the dispirited way of some plantainlilies.

HOSTA NAKAIANA F. Maekawa (Fig. 5) has been distributed as *H.* "Nakaimo Minor". It is a delightful small plantainlily, blooming about two weeks earlier than "Nakaimo", and quite similar to it. The leaves are less

PHOTO GERTRUDE WISTER

Fig. 5. *Hosta nakaiana* in fruit. The seed pods are crowded at the tops of the scapes.

cordate, about 3½ inches long by 2½ inches wide on 7-inch petioles, making an 8-inch mound. The scapes rise to about 2 feet, bearing up to 15 flowers crowded into the top two or three inches. The flower color is light purple, a little deeper than that of "Nakaimo", and the expanding flower clusters with their light bracts are very attractive. It produces an abundance of good seed. Part of the seedlings should come true.

PHOTO GERTRUDE WISTER

Fig. 6. The dime in the center pot gives scale to the five-year-old seedling of *Hosta venusta*. To the right is an *H. venusta* seedling with slightly larger leaves. To the left is a young division of the slender-leaved *Hosta longissima*.

HOSTA VENUSTA F. Maekawa. (Fig. 6). Smaller than *H. nakaiana,* and variable in size, down to miniatures making leaf mounds only three or four inches high, with six-inch scapes. A plant of average size gives scapes about 8 inches high, and leaves about 1½ inches long, and a half as wide, on 3-inch petioles. Our oldest plant is somewhat larger than this (leaf mound to about 9 inches) but has given seedlings varied in size (not counting the obvious hybrids) some very small. The smallest plants are less liable to produce seed. Bloom is the latter part of June.

PHOTO PAUL E. GENEREUX

Fig. 7. *Hosta sieboldiana* 'Frances Williams' maintains its effective color contrast throughout the summer.

HOSTA SIEBOLDIANA (Hook.) Engler 'FRANCES WILLIAMS' (G. W. Robinson). (Fig. 7). Sold also as *H. s. aureo-marginata* or as *H. s.* "Gold Edge" or "Yellow Edge." It bears the name of Mrs. Frances Williams, who for many years was an enthusiastic grower of plantainlilies. She picked it out from a batch of *sieboldiana* seedlings at the Bristol Nurseries. The leaves are broadly and irregularly margined with greenish yellow which matures to strong yellowish green. The contrast with the center of the leaf is good throughout the season. Leaf mound and scapes are about the same height, the flowers nearly white. It is possible to get gold-edged or all-yellow seedlings from this plant. 'Golden Circles', broad gold-edged, is one of these.

HOSTA 'ROYAL STANDARD' (Wayside Gardens). This hybrid has some of the fragrance of one of its parents, *H. plantaginea*. It looks like a very large "Minor Alba", with 42-inch scapes rising above the 30-inch leaf mound. It makes a large-leaved, free-flowering, big, stately plant. Bloom begins in mid-August.

HOSTA 'BETSY KING' (F. R. Williams) is a chance seedling found by Mrs. Williams in her garden, and, I think, the finest representative I have seen of what I call August Hybrids for my own convenience. This well-proportioned plant has heart-shaped leaves about 7 inches long by 5½ inches wide, on 15-inch petioles, making a mound about 15 inches high. The erect scapes, about 20 inches high, appear in late July, bearing slightly cupped flowers resembling those of *Hosta decorata*. They are solidly colored light to moderate purple outside; there are six white stripes inside where the segments are joined.

PHOTO PAUL E. GENEREUX

Fig. 8. Warm weather turns the cool weather yellow and green contrast of *Hosta fortunei* 'Albopicta' *(H. f. viridis marginata)* all green, but in spring and early summer it is a striking plant.

HOSTA FORTUNEI (Bak.) Bailey 'ALBOPICTA' (Miq.). (Fig. 8). This is usually known in this country as *H. f.* 'Viridis Marginata'. During the early spring and until the foliage is fully matured, the leaves of this large-leaved hosta are very pale green in the center, edged with darker green, making a very effective plant. The pale center may last longer in cooler climates than ours, but by early June here the color contrast is about gone. The flowers, like most of those of the *fortunei* group, are very pale purple with faint stripes inside.

HOSTA VENTRICOSA Stearn Syn. *H. coerulea* (Andrews) Tratt. Other hostas may also be sold under the name *H. coerulea*. A large plant with glossy deep green leaves twisted at the tips, about 10 inches long by 8 inches wide. Above the two-foot mound the scapes rise in early July to about 3 feet. The flowers, not blue as often claimed, but light purple outside and moderate purple inside, are distinctively bell-shaped, the main part of the flower swelling out abruptly from a narrow tube. The seeds of this species give a perfectly uniform progeny, but it will pollinize other plantainlilies, giving hybrids. I have often seen large stands in semi-wild situations. There is no mistaking it. It is a native of China.

HOSTA "MINOR ALBA" (Hort.) winds up my list, but surely is not last in my affections, although the fragrant plantainlily is first. I am sticking to the name for it long known and widely used in catalogs, which has no botanical standing. It is known only as a garden plant of mysterious origin in the Western Hemisphere. In this country, it must be considered a strain, having been grown from seed, and the white-flowered seedlings selected for sale. At its best, it is a foot-high mound of slender leaves about 6 inches long by 1½ inches wide topping 8-inch petioles. In August the erect scapes rise from 24 to 30 inches, bearing up to 20 pure white flaring flowers. It is a pretty thing, and a gem for late-summer shade. Two clones, 'Snowflakes' and 'Tinker Bell', are seedlings from it.

I have omitted many well-known hostas. There is much information about these in Mr. Lee's article of October 1957, which was reprinted in the July 1967 issue. The captions of Plates 6 and 7 were reversed in the earlier issue.

Among the Very New and Scarce

It is interesting that among newcomers from Japan there are so many small species and varieties. The following are low-growing very attractive additions to the shady garden:

HOSTA LANCIFOLIA var. *THUNBERGIANA* f. *SUBCROCEA* F. Maekawa. The foliage stays a brilliant yellow green all summer. The growth of this little plant is very slow because of the low amount of chlorophyll it contains. The leaves are about 3 inches long by ¾ of an inch wide. The flowers appear in mid-August. This plant has been circulating under the name *H. tosana,* which is a name for another species.

PHOTO GERTRUDE WISTER

Fig. 9. The small-leaved *Hosta* called Kabitan by the Japanese retains its attractive color contrast all summer.

HOSTA LANCIFOLIA var. *THUNBERGIANA* f. *KABITAN* F. Maekawa (Fig. 9) is a most unusual small plant. Its slender leaves are brilliant yellow-green edged with moderate olive green, giving a good contrast. It, too, grows slowly, and produces its flowers in mid-August. It has circulated as *H. clavata,* which is not this plant but another species.

HOSTA LONGISSIMA Honda. (Fig. 6). This plant is new in our garden, and it will take two or three years for it to assume anything like a typical appearance. The leaves are said to reach over a foot in length, but I think this includes the petiole, into which the very narrow leaf tapers. The mound is supposed to be about a foot high, the mature leaf blades an inch or less in width. Bloom is in late August, and the scapes are said to reach 20 inches.

The following plantainlilies are larger and taller than the preceding.

HOSTA TOKUDAMA F. Maekawa. Syn. *H. sieboldiana glauca* Nakaimo. Syn. *H. glauca* Hort. not Stearn. A neat plant, smaller than *sieboldiana,* with intensely glaucous rounded leaves, cordate at the base, about 8 inches long that tend to turn up around the edges like saucers. It is slow growing and compact, making a mound about 15 inches high. The very pale purple flowers appear in late June on scapes a foot to 18 inches high.

PHOTO GERTRUDE WISTER

Fig. 10. A neatly scalloped leaf of *Hosta* 'Green Pie Crust'.

HOSTA 'GREEN PIE CRUST' (F. R. Williams). (Fig. 10). This chance seedling found by Mrs. Williams in her garden is notable for the neatly rippled edges of the large heart-shaped leaves. It is the offspring of the wavy-leaved plant known as *H. fortunei* var. *gigantea* Bailey, more correctly called *H. elata* Hylander.

HOSTA 'KROSSA'S REGAL' (Fig. 11) may also be called "Tall Regal",

PHOTO GERTRUDE WISTER

Fig. 11. *Hosta* 'Krossa's Regal' makes a handsome mass of blue-gray foliage.

"High Boy", and "Krossa's A-3". This plant, probably a hybrid of *H. nigrescens* (Makino) F. Maekawa, is notable for the heavy gray-blue dusting of leaves, petioles and scapes. The leaves, about 10 inches long by 5 inches wide, are borne high on long petioles, giving a regal look. Scapes are very tall, to 50 inches, bearing very pale purple flowers in late August. The plant is sterile, or nearly so.

These are only a sampling of the plantainlilies that have entered the garden scene during the past ten or fifteen years. Naturally, I have mentioned the ones that seem to be most interesting.

Small Hostas From Seed

Small hostas are scarce, and the true species can be increased by seed. However, the writing of this article has brought me to realize that I must relocate some of our small ones before they bloom this spring. Those that bloom at the same time should be kept as far away from each other as possible. Seedlings of a small hosta that are hybrids with a larger species can be easily separated from the self-pollinated seedlings on the basis of size alone. But two small species crossed together could produce a hybrid population without notable distinguishing characteristics.

It is difficult to get good seed from late-blooming hostas. If seeding stalks are cut and brought inside, they will stay green for several weeks in a jar of water in a sunny window, giving a greater chance for seed to mature. A stalk of *H. plantaginea* I cut in mid-September stayed green until early November, and when I opened the pods, seeds were germinating inside them. Of course several hostas bloom later than *H. plantaginea,* and might be picked at a later date, but before cooling weather has slowed down their development too much.

Hostas Of The Future

We have yet to learn, out of the wealth of new material that is appearing, what plants will be distinctive compared with those already available. There will be too many clones named by their enthusiastic originators or discoverers. But that happens in many plant groups, and in one where vegetative propagation is slow, it may have a value not present in the other groups.

Those breaks in flower color, if and when they come, will change the hosta picture to an extraordinary extent. Tetraploids, too, could make a difference, with foliage of heavier texture, and perhaps longer-lasting flowers.

In the meantime, there are those unpredictable sports to watch for, and those especially attractive seedlings. Some of the variegations will prove unstable. But one should not be too quick to discard. Sometimes a plant newly divided or moved to a new location will take a year or two to demonstrate what its final appearance will be.

Culture

Given light to medium shade, especially in the hottest part of the day, and a moderately good soil that does not dry out, hostas thrive. Unlike many perennials, they can stay in the same spot for years without being divided. The large leaved kinds expand to make clumps five or six feet across in time, a point to bear in mind when placing them. Large leaved kinds and those with variegated leaves are apt to burn if exposed to two or three hours of unbroken sun each day. Very deep shade means less bloom, perhaps none, but a ground cover of green is possible even under quite low branches.

Although dividing and transplanting is best done in spring or fall, hostas can also be divided during the summer, with attention to extra watering. If the plant divided is old and thick, a season's growth will be needed to restore the divisions to good appearance. Younger plants can be divided with care, to give new growth in a few weeks' time.

In general, pests and diseases are a minor problem. Slugs and snails may need control with slug bait. Sometimes leaf hoppers congregate on the flower stalks, and a spray such as Malathion is called for. Crown rot may attack, but I have never lost a hosta to it. A wilted or yellow leaf or two is the first symptom. These leaves pull away easily, and examination of the leaf base shows a gray webbing. From the webbing, small round bodies are formed, first white, then yellow, then brown, which give the common name, mustard seed rot. Care should be taken not to scatter infected leaves. All affected material should be carefully dropped in a paper bag and burned or sent out with the garbage, not put in the compost pile. This rot can attack iris, ajuga, delphinium, ferns, and many other herbaceous plants.

To combat mustard seed rot, I use a drench of Terraclor at the rate of one tablespoon to a gallon of water. Make a slurry of the powder with a little water, then stir in the rest of the water. It must be stirred up frequently, as the powder tends to settle out. Soak the affected plant, and the soil surrounding it.

Hostas are adapted to a wide area. Members of the American Hosta Society come from 37 states, from Louisiana and Arizona to California, Montana, the Dakotas and Maine even to Alberta, Canada. Most members live in the colder states. Hostas planted in autumn should be well mulched for the first winter to prevent heaving from frost. Mulches in the coldest areas are probably always desirable, but here in the Philadelphia area we give no extra protection to established plants.

Hostas can survive years of neglect and unfavorable conditions, but they will not be at their best. With attention at the beginning to their simple needs, and a few deep waterings in dry spells, they will give decades of satisfaction.

To Join the Hosta Society

Dues in the American Hosta Society are $3.00 for regular members, $10.00 for sustaining members. Checks should be made payable to the society and sent to Mrs. Eldren W. Minks, 114 The Fairway, Albert Lea, Minnesota 56007.

Sources of Hostas

Maxine Armstrong, 8021 Lake St., Omaha, Nebraska 68134.

Englerth Gardens, Rt. 2, Hopkins, Michigan 49328.

Mrs. Glen Fisher, 4392 West 20th St. Road, Rt. 3, Oshkosh, Wisconsin 54901.

Lamb Nurseries, East 101 Sharp Ave., Spokane, Washington 99202.

Parry Nurseries, Signal Mountain, Tennessee 37377.

Savory's Greenhouses, 5300 Whiting Ave., Edina, Minnesota 55435.

Alex J. Summers, 14 I. U. Willets Rd. West, Roslyn, New York 11576.

Weston Nurseries, East Main St., Hopkinton, Massachusetts 01748.

Hosta Collections Open to the Public

Alfred L. Boerner Botanical Garden, Whitnall Park, Hales Corners, Milwaukee, Wisconsin.

The Arnold Arboretum, Case Estates, Weston, Massachusetts.

The Scott Horticultural Foundation, Swarthmore College, Swarthmore, Pennsylvania.

The University of Minnesota Landscape Arboretum, Chaska, Minnesota.

Waterworks Park, Des Moines, Iowa.

U.S. National Arboretum, Washington, D.C.

References

1. Bulletins of the American Hosta Society. Issued annually by the Society; Vol. 1 was published in March 1969.
2. Fisher, Eunice V. 1967. Hostas—Aristocratic Plants for Shady Gardens. Published privately.
3. Hensen, K. J. W. 1963. De in Nederland gekweekte Hosta's. *Meded. Directeur Tuinb.* 26:725-735. A synopsis of the hostas cultivated in the Netherlands.
4. Lee, Frederic P. 1957. Plantainlilies. *Natl. Hort. Mag.* 36 (4) :313-333; reprinted in *Am. Hort. Mag.* 1967. 46 (3) :143-163.
5. Ohwi, J. 1965. Treatment of *Hosta* in Flora of Japan (in English). Smithsonian Institution.

Some Memories of the Plant World

ORLAND E. WHITE*

My earliest memories involve a garden, one in which I could plant anything I pleased—wild flowers, cultivated flowers, vegetables, shrubs, and trees. [Doctor White was born at Sibley, Iowa, April 25, 1885.] At first it was a small garden; later the world was my garden, as it was for David Fairchild. My wife and I traveled over the gardens of the world, both natural and cultivated, and photographed them. I have excellent recall of where we went and what we saw.

My parents loved gardening and plants, and it was at my mother's knee that I learned how to key plants down. Wherever she went my mother painted and planted flowers; my father planted trees and shrubs. When I was growing up in South Dakota, I used to dream of planting the country roadsides with fruit and ornamental trees.

I spent a season [1904] working in the Yankton Nursery, which is still in business, and lived with the family of Mr. George Gurney, the owner, who gave me a letter to Professor Niels E. Hansen, Head of the Department of Horticulture, South Dakota State College of Agriculture and Mechanics at Brookings. Mr. Gurney asked me to come back the next year, but, except to visit, I never went back. I took all the horticultural courses offered by Doctor Hansen and in the spring became his assistant and crossed fruit trees and test-tasted the fruits of hybrid strawberries. Doctor Hansen was especially interested in producing hardy fruits and agricultural crops for the northwest plains. In later years I devoted much time to the study of plant hardiness.

* 1708 Jefferson Place
Charlottesville, Virginia 22903

The next year I enrolled in the regular college courses, with the idea of majoring in botany. I was particularly interested in plant breeding [read Mendel's paper *ca.* 1907], but I realized that it was necessary for me to have a general scientific education. Under W. A. Wheeler and E. W. Olive, I took many botanical courses and graduated in 1909 with a major in botany and two years later a Master of Science degree in the same field.

I wanted to be a geneticist and, accordingly, studied tobacco species under Professor E. M. East at Harvard for three years, after which (1913) I was granted a D. Sc. degree and let loose on the world. At this point Dr. E. W. Olive was influential in obtaining for me a position on the staff of the new Brooklyn Botanic Garden where I had charge of plant breeding and economic plants for fourteen years. I then went to the University of Virginia as Professor of Agricultural Biology and Director of The Blandy Experimental Farm at Boyce, Virginia from 1927 to 1955. That turned out to be another adventure with plants and people.**

** Doctor Orland E. White made a unique institution of Blandy Farm. That it was located in Clarke County, Virginia, about ninety miles by road from the University of Virginia in Charlottesville, had its advantages. The Director was left largely to his own devices, though he had the guidance of a University Committee, of which the late Bruce D. Reynolds was the able Chairman. Rapport between the two men was excellent.

The Director was fortunate in another respect. He attracted a succession of able graduate students who on occasion differed with him but who with few exceptions have held him in high respect. He is truly one of the great teachers of botany that this country has produced. His students have held significant positions in horti-

Among the thousands of tropical trees, shrubs, and vines that I have seen, the ones of tropical America were by far the most interesting to me as contrasted with those of the semi-tropical and tropical parts of the five continents that Mrs. White and I visited.

Our favorites are from various regions and include several members of the pea family. Trees of *Delonix regia,* the flamboyant, often line the streets of the tropical world; it is a native to Madagascar. This tree, also known as the royal poinciana, has huge racemes of scarlet and orange flowers and woody pods often two feet long. Another is *Cassia fistula,* the golden shower tree of the East Indies, sometimes called purging cassia, because its seeds are embedded in a laxative pulp. Yet another is the rare *Amherstia nobilis* of Burma, with masses of red or pink flowers tipped with gold.

Then there are the morning-glory trees (*Ipomoea* spp.) of Mexico with great white flowers. Many members of the trumpet-vine family (Bignoniaceae) are planted all over the tropical world, including the brilliant orange-flowered *Pyrostegia ignea* of South America. Likewise, *Kigelia africana,* the sausage tree, is cultivated throughout tropical countries for its most beautiful blue-red flowers in long racemes and fruits a foot long that resemble the form and shape of a sausage roll. *Spathodea,* the tulip tree of Africa, is widely planted in all tropical countries for the blossoms that decorate the ground with fallen orange, tulip-like flowers.

Bougainvillea of South America are relatives of four-o'clocks. They have been exuberantly planted everywhere below the frost line, because of the purple and red and orange floral bracts that these woody vines produce in great profusion. Finally, I mention *Adansonia digitata,* the baobab or monkey-bread tree of Africa, grotesque but handsome with short and squat trunks that sometimes have a diameter of thirty feet. This unusual tree is a member of the silk-cotton family (Bombacaceae), the same family that produces kapok.

The Lecythidaceae or Brazil-nut tree family is a group of plants fascinating to me. I first knew these trees as living specimens when I went on the Mulford Biological Exploration to the Amazon Basin in 1921-1922. The Brazil-nut, *Bertholletia excelsa,* is one of the largest trees of South America, and best known representative of the family; I first observed it on that expedition. Its fruit is a woody capsule four to six inches in diameter, with twelve to twenty-four seeds inside. When a Brazil-nut fruit drops, it sounds as though a cannon had been fired. Since the fruits ripen in January during the rainy season, they partially bury themselves in the forest floor. Gatherers wearing wooden hats rush in to harvest the nuts by cutting the fruits open with machetes. During my time in the Amazon, the nuts were loaded in dugouts, then in riverboats, and shipped by steamer to North American and European markets. When loaded loose in the holds of ocean steamers, the masses of nuts were continually shoveled to prevent heating. The woody nuts have a small aperture in one end through which roots emerge at the time of germination. Through these small holes small cockroaches would enter to eat up the debris.

Lecythis is a genus of medium-sized to very large trees, related to the Brazil-nut, some with buttresses six feet in

---

culture, in agriculture, and in the academic world. Their training at Blandy and at the University was so broad that they might later go in almost any direction that they might choose—and they have. The Blandy Fellow's investigations were most often an amalgam of genetics, cytology, and taxonomy. And the students learned how to grow plants!

That The Blandy Experimental Farm was soon world-known is not surprising. However, after World War II, scientific activities at the Farm slowed down and finally halted. Presently there is promise that the Farm will be rejuvenated.

The farm itself, a generous gift of Graham Blandy by will to the University and with an endowment, consists of about seven hundred acres, of which about six hundred acres are a productive farm—one of the best in the region. The remaining acres are the Orland E. White Arboretum and experimental areas. [J. T. Baldwin, Jr., College of William and Mary, Williamsburg, Virginia.]

diameter and with trunks limb-free for seventy feet. Some of the species produce sapucaia nuts or paradise nuts (*L. zabucajo* and related species) ; these are edible and resemble dried gray prunes. The nuts are exported to Europe and can be bought in larger cities at high prices. Monkeys harvest many of them in the forest. Sometimes one sees these nuts in resort places where they have been sprayed with rose perfume and are then called rose-nuts and are sold at exhorbitant prices per nut. Sapucaia nuts are produced in thick woody fruits eight to nine inches in diameter and about six inches high. When ripe, the fruits retain their hold on the tree, but the round lid falls free like the lid of a cooking pot allowing the ripe nuts to fall out. Monkeys then rush in to get the ripe nuts. Size of the fruit varies from species to species of *Lecythis*. In those with pipe-bowl-size fruit, the lid resembles a railroad spike, and the so-called nuts are very small like the end of a maple fruit.

The cannon-ball tree (*Couropita guianensis*) is another member of the Brazil-nut family. It is a most remarkable tree with flowering branches surrounding the main trunk; these branches arise from the bark, not the wood, and live for many years. The large flowers are two inches across with petals salmon-pink on their inner surface and white with yellow markings on the outer surface. The fruits resemble rusty cannon-balls six to eight inches in diameter and require about eighteen months to ripen. When the fruits fall, they make piles around the base of the tree. The seeds are embedded in fetid pulp that becomes nauseous. The fruit is of no economic value.

Besides these trees in the Lecythidaceae, there is one from which the Indians in bygone days stripped the bark, pounded it in water, and made dresses after stretching and block-printing the bark. I have dresses made by the Yuracare Indians of the Upper Bene River region. These Indians are wards of the Bolivian government under the supervision of the Franciscan missionaries near the village of Cobendo. Dresses could be bought through the Franciscan missionaries in 1921-22 but probably now are very rare.

I close this short sketch of some of the plants most interesting to me from the thousands that I have seen with a few words about the giant *Puya raimondii*, a spectacular member of the Bromeliaceae, the pineapple family. My wife and I hired a special car from the Arica-La Paz Railroad to see the plant on a granite mountain along that railroad. It has a limited distribution in Bolivia and Peru. When the plant gets to be 45 or 50 years old, it sends up a flowering stalk about 35 feet high and strong enough to support a ladder leaned against it (Back Cover). The inflorescence is covered with small white flowers; after setting millions of minute seed the whole plant dies. In the mountain quarry visited, we saw various stages of this curious and most memorable plant growing right out of the granite.

ERRATUM

Vol. 50, No. 2, page 83. Read last line under Parentage (tetraploid, $4n = 60$).

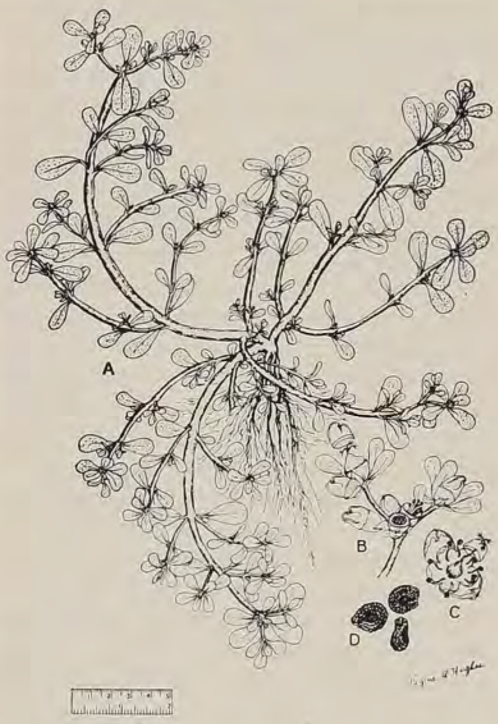
Control Weeds to Save Water

Weeds compete with the desired plants in your garden for water, light, nutrients, and space. Weeds and domestic plants vary in their ability to compete for soil moisture. Some weeds such as common chickweed (*Stellaria media*), common lambsquarters (*Chenopodium album*), redroot pigweed (*Amaranthus retroflexus*), and other annual weeds grow best in moderate soil moisture levels. Most annual vegetable plants such as beans, melons, and vegetable leaf crops, and such annual ornamental plants as petunias, marigolds, coleus, and others show a similar response.

Certain weeds such as common purslane (*Portulaca oleracea*), field horstail (*Equisetum arvense*), Russian thistle (*Salsola kali*), spotted spurge (*Euphorbia maculata*), and others thrive at low soil moisture levels. Some domestic ornamental plants such as sedum, portulaca, cacti, bearded iris, and others also grow well at these moisture levels. Few annual vegetable crops survive these conditions.

There are weeds well adapted to compete for moisture with domestic plants of all kinds. Therefore, control or removal of weeds is necessary for optimum growth of domestic plants and for maximum conservation of soil moisture.

The use of mulches of various kinds is an excellent way to control some kinds of weeds and conserve moisture in the home garden. Organic mulches include cereal straw, wood chips, peat, pine bark, and cocoa bean hulls. Cereal straw should be steam sterilized before use or used in combination with an acceptable grass-killing herbicide such as dimethyl tetrachloroterephthalate (DCPA) isopropyl *m-chlorocarbanilate* (chlorpropham), *N,N*-dimethyl-2,2-diphenylacetamide (diphenamid), 4-(methylsulfonyl)-2,6-dinitro-*N,N*-dipropylaniline (nitralin) and others as labeled for use on domestic plant species involved.



Common purslane, (*Portulaca oleracea*)
A. Growth habit
B. Flowers and capsules
C. Open Flower
D. Seeds

Mulching paper, black polyethylene sheeting, and aluminum foil are also effective in controlling weeds and conserving moisture (see *Am. Hort. Mag.* 47 (3):307-304).

Because none of the mulches give overall weed control, a certain amount of handweeding and/or a limited use of herbicides is always necessary.

Control of Common Purslane

This plant is a good example of a weed that competes strongly with domestic plants for soil moisture and nutrients with only a limited amount of competition for light among low growing plant types. In long periods of continuous low soil moisture conditions, purslane survives and may even thrive when growth of ornamental and vegetable plants is severely reduced or stopped. It is found in all of the continental United States but is most prevalent in the eastern half of the country. It grows in crop and noncrop areas, including gardens, lawns, and along roadways.

Common purslane is an annual weed that reproduces from seeds. New plants will also develop from stem root fragments produced by hand or mechanical cultivation. The stems are round, fleshy, and purplish red. They arise from a taproot. Plants are freely branched, prostrate, and 4 to 10 inches long. The leaves are alternate or nearly opposite, sessile, much thickened and watery as in sedum, smooth, often clustered at the ends of branches, and range up to approximately one inch in length. The flowers are yellow, sessile, and occur singly in leaf axils or several together among leaf clusters at the ends of branches.

Seeds are produced in large numbers in a globular capsule. They are about the size of petunia seeds, and black, with a whitish scar at one end. The coat is covered with curved rows of minute wrinkles.

Flowering and fruiting occurs from June or July until frost in moderate to cool regions. In high temperature regions flowering and fruiting occurs from April to June and ceases during the hottest part of the summer, beginning again in late summer and continuing until frost.

Mulches are effective in controlling common purslane in vegetable and ornamental plantings. Weekly hand weedings are also effective. Some herbicides such as 2-chlorocallyl diethyldithiocarbamate (CDEC), chlorpropham, DCPA, diphenamid, *S*-propyl butylethylthiocarbamate (pebulate), and others used as soil treatments will kill common purslane seed during germination. Lists of domestic plants tolerant of each herbicide are printed on the manufacturer's label. These lists serve as guides in selecting appropriate herbicides for use in home gardens. Carefully follow the directions on the manufacturer's label. When in doubt, call your local county extension agent.

Mention of a 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.

All agricultural chemicals recommended for use in this report have been registered by the U.S. Department of Agriculture. They should be applied in accordance with the directions on the manufacturer's labels as registered under the Federal Insecticide, Fungicide, and Rodenticide Act.

LORAN L. DANIELSON
Plant Physiologist
U. S. Department of Agriculture
Beltsville, Maryland 20705

From *The National Horticultural Magazine,* Volume 2, Number 4, Fall and Winter, 1923:

HOW TO WINTER PANSY PLANTS

J. D. Long, C. F. N. H. S., Boulder, Colo.

More pansy plants are killed by coddling than by neglect. Wanting to be ever so kind, many pansy lovers cover the plants too heavily and smother them.

It should be kept in mind that pansy plants will stand a lot of cold. What kills them is the alternate freezing and thawing, and whipping of the wind. If beds are covered long with ice or icy snow the plants will die. Pansies need air, and therefore should not be covered with material that packs closely. Great care should be exercised in the use of leaves. When they are wet the air is excluded and this will lead to death and decay. It is better to cover first with brush if leaves are used.

It is preferable to cover with brush only, or dahlia stalks, or something equally coarse. Very small plants should be covered with coarse excelsior, torn to shreds and spread just thick enough to barely hide the ground. This covering may be held in place with poultry wire well staked.

Covering should be delayed until very late in the fall, and should be removed early in the spring. It is advisable to keep the plants tough by letting them rough it as much as possible.

Clerodendrum philippinum—Correct name of the single and double forms of "Clerodendrum fragrans"

A shrub known as "Clerodendrum fragrans," hardy in tropical and subtropical areas, has been in cultivation for nearly 200 years, most of the time under that incorrect name. The plant was described and first illustrated with a colored plate by Nicolaus Jacquin in 1798 as a plant from Japan cultivated at the Royal Gardens at Schönbrunn, near Vienna, Austria. These gardens had been created by Francis I, the first Holy Roman Emperor of the House of Loraine. The name *Volkmannia japonica* was applied to the plant. The same plant was redescribed by the botanist Etienne Ventenat in 1804 from a specimen growing in the garden at Malmaison, the palace garden of the Empress Josephine at Versailles, France. Ventenat called the plant *Volkameria fragrans.* Both specific names have been used incorrectly, according to the International Rules of Botanical Nomenclature, in the genus *Clerodendrum,* and the correct name which must be adopted in *Clerodendrum philippinum* Schauer. (Howard & Powell, *Taxon* 17: 53-55, 1968). The specimen Schauer saw was from the Philippines and may have been introduced and cultivated.

The specimens described independently by Jacquin, Ventenat, and Schaur are double-flowered forms which are nearly always sterile. Fortunately, the plant is reproduced readily by cuttings or divisions, and, thus, it is known in cultivation in Florida and the Gulf Coast area as well as in tropical botanical gardens around the world. The plant is found established as a roadside weed in the West Indies and it also persists after former cultivation. The foliage is soft, pubescent, and when crushed gives a rank odor. However, the specific epithet "fragrans" is applicable as the double white flowers, often with a pink or pink-purple tinge, have a subtle sweet aroma in the late evening hours.

Double flowered forms in which the extra petals are usually divided petals or modified petaloid stamens or pistils are known in many cultivated plants. When these are the first forms described the scientific name applies to the double form. If a single or normal flowered form is found later, such a specimen is described as a variety or a form. The single flowered form of *Clerodendrum*

PHOTO R. A. HOWARD

***Clerodendrum philippinum*. Close-up of inflorescence.**

philippinum is represented by many herbarium specimens all collected in China, but it has been given a scientific name only recently by Dr. Harold Moldenke based on a specimen from Thailand (*Phytologia* 20: 338. 1970). It is known as *Clerodendrum philippinum* var. *simplex* Moldenke. Other well known examples of cultivated plants where the species has double flowers and the variety single flowers are *Spiraea prunifolia* Sieb. & Zucc. (double) and *Spiraea prunifolia* forma *simpliciflora* Nakai (single) or *Rhododendron yedoense* Maxim. (double) and *Rhododendron yedoense* var. *poukhanense* Nakai (single).

The double flowered form of *Clerodendrum philippinum* is also called, incorrectly, *Clerodendrum fragrans* var. *multiplex* Sweet, *Clerodendrum fragrans* var. *pleniflora* Schauer, and *Clerodendrum japonicum* var. *pleniflorum* Maheshwari in various books on cultivated plants.

RICHARD A. HOWARD
Director
Arnold Aboretum of Harvard University
Jamaica Plain, Massachusetts 02130

From *The National Horticultural Magazine,* Volume 5, numbers 1-4, January-December, 1926:

SECRETARY'S MESSAGE

Now that the union of The National Horticultural Society and The American Horticultural Society is complete, and with the publication of this, the first copy of The National Horticultural Magazine since the merger, it is opportune to look ahead and plan our course for the future. The aim of the society is to promote Horticulture in all its branches and our success in this effort can be measured primarily by the number of members we have who are willing to support this work and secondarily by the officers who are chosen to direct the destinies of the organization.

This magazine will serve to make a more intimate contact between the members and the executive branch of the society. This factor is a necessity to keep a genuine interest aroused. It is the plan in the succeeding issues to carry a roster of the membership, a history of the society, and other items of interest concerning the executive activities of the organization.

Early in 1927, now that we have the magazine as our herald, a membership campaign should be launched. In this every member can serve. It is by building up a large organization of persons in all walks of Horticulture that The American Horticultural Society can become the power that it should be in this country. The road is open and wide for rapid progress.

At our annual meeting to be held in February new officers will be elected for the ensuing year. A notice of the offices to be filled has already been sent you and the voting will take place during January. The officers to be elected for 1927 will need the support of our entire organization to build up and strengthen our young but growing society.

D. VICTOR LUMSDEN, *Secretary*

Garden Notes

The Queensland Umbrella Tree, *Brassaia actinophylla*

In a Florida garden stands an exceedingly handsome tree with glossy "tropical looking" foliage. It grew from seed and rose right straight up like a bean pole, up and up until it was nearly 25 feet high with no branches. True, it did have leaves all the way up the trunk, great big leaves two feet across, made up of 15 or 20 leaflets hung radially on the end of a 2-foot stem so that each leaf looked like an umbrella. These leaves are arranged symmetrically around the trunk to make a balanced green column.

For a costume ball one night the owner cut off the clustered leaflets just at the end of one of these stems, inverted this and wore it as a hat that won a prize.

Out in Queensland, Australia, where this tree is native, it is called umbrella tree (*Brassaia actinophylla,* syn. *Schefflera actinophylla*). The plant was introduced to the United States in 1927 by Frank Walsingham, and quickly became the most popular of pot plants.

The Florida specimen grew apace until a hurricane one summer day broke off the top half. This caused the stump to branch. The tree never had branches before and now it suddenly developed half a dozen. In the intervening years

The Queensland umbrella tree *(Brassaia actinophylla)* with 3-foot plumes of red flowers from the top of its stem. The tree flowers only at maturity if planted in full sun.

these have grown massive, and the original bean pole has become a lovely, spreading shade tree, incomparable for form.

When the tree was about 15 years old it began to bloom, which this species never does unless growing in full sun, but no one could predict when it would flower. One year blossoms came in March, another time in August, and on several occasions the tree flowered twice the same year. The small red blossoms clustered on great spikes 2 or 3 feet long, flow out the top of the trunk or main branches like so many ostrich plumes, and their intense color against a bright blue sky and offset by handsome foliage make a striking picture. Gradually the red flowers became red fruits over a period of six weeks or more, and these finally turn black, still soft and squashy like raisins but definitely ripe. The tree knows this too, but instead of shedding the individual fruits, it drops the long fruiting spikes and these shatter some as they clutter the ground around the mother tree. In every little fruit there are a dozen papery seeds, not yet ready until the pods are thoroughly dry.

Now to reveal a trade secret! The seedpod branches are gathered and laid on cardboard on the floor of the garage. Then the clustered pods are pulled off, packed in a box, and mailed to a florist in Switzerland—of all places! He shells out the seeds, plants them, and year after year he produces 10,000 plants from seed grown in Florida on an Australian tree! What does he want with them? He sells them for house and patio plants, to be grown in tubs or pots, and they do marvelously well in this capacity.

Here is a subtropical plant of great merit that can be grown indoors in the temperate zone, in pots, tubs or shubberies, in patios or conservatories, anywhere the temperature does not go below 18° F, because the umbrella tree is used to extremes of warm and cool weather. By growers all over the United States it is considered the most satisfactory plant ever introduced from abroad for ornamental planting, because it can be used many different ways. Even in Florida it is found growing against foundations and in corners, producing its array of handsome foliage, dark green and shining. It appears in window boxes, tubs, and patios. When it starts to get big it can always be dug up and moved outdoors. A look of consternation always crosses the faces of Florida visitors when they look at a huge umbrella tree and suddenly realize that this is the "shrub" a high-priced landscaper planted in a spot by a picture window back home.

After the tree develops big branches after the top is broken out, each branch suddenly starts to develop auxillary (adventitious) roots. These roots emerge several feet up from the base on side branches 6 to 8 inches from the main trunk. Roots come out from every direction. If allowed to grow these auxillary roots will take hold in the ground if they have opportunity. These roots may circle the tree trunk and try to choke the parent. These adventitious roots can be cut away, but on occasion a limb having bunches of roots near the union with the trunk is cut off and planted to produce another tree. This phenomenon of developing auxillary roots probably would never happen in plants grown in containers.

The umbrella tree is a good example of a tropical tree that sometimes begins its life as an epiphyte or as an "air-plant." If one of the seeds is dropped by a bird into a crotch of a nearby tree and finds moisture and accumulated debris to nurture it, germination takes place and an umbrella tree begins to grow. As the young tree grows, its roots will grow down the trunk of the host tree until they reach the ground. As soon as the roots reach the ground, the umbrella tree begins to grow in earnest. It drops more roots, and these will gradually encircle the "host" tree and choke it to death. The umbrella tree that began as an air plant will become the giant of the forest, and the tree that mothered it as a baby will die and rot away.

EDWIN A. MENNINGER
219 Martin Avenue
Stuart, Florida 33494

Wyman's Gardening Encyclopedia

Donald Wyman, The Macmillan Company, 866 Third Avenue, New York, N.Y. 10022, 1222 pages, 1971, Illustrated, $17.50, (Library).

This is a well written gardening encyclopedia by an author, Donald Wyman, Horticulturist Emeritus of the Arnold Arboretum, who is well known for his horticultural magazine articles and books. In preparing this book he has had the help of 22 others, experts who have contribued from their own horticultural speciality to make this as up-to-date as possible for a book of this type.

More than 9,000 plants are listed alphabetically by genus name with the scientific name, a common name, a description and cultural information. Common names of the plants are included in the lists with references to the correct genus. All types of plants are included, annual, perennials, and woody kinds, those of ornamental and economic value, those from the north and those grown in the tropics. It is intended to encompass plants grown in the United States and Canada but will find use elsewhere.

Dr. Wyman indicates in his acknowledgements, that he had an opportunity to check the scientific names with the manuscript being prepared for Hortus III. In this way, the encyclopedia is as up-to-date as possible on the correct scientific names and this aspect of the book will keep it modern for a very long time. The omission in the plant description of the family name will not be important to users of the book but it would have added greatly to its value as a technical reference.

Gardening terms are defined, horticultural practices explained, and general culture including pest control of the plants described. The author has spent many years studying and evaluating plants for their horticultural values and he includes 45 lists of plants for specific purposes, most of which include common and scientific names, plant height and hardiness zone. The hardiness zone map of the Arnold Arboretum,— the Rehder-Wyman map,—is on the inside of the covers of the book, making it easy to use.

Wyman's Gardening Encyclopedia is authoritative and up-to-date. It is the newest reference for horticultural information and one that can be expected to be useful for many years.

CONRAD B. LINK

Printed Books 1481-1900 in the Horticultural Society of New York

A listing by Elizabeth C. Hall. Published by the society, 128 W. 58th St., New York, N.Y. 10019, 1970. 279 pages, $16.00. (Library)

A catalog of the collection of approximately 4000 volumes, arranged alphabetically by author of botanical and horticultural books published between 1481 and 1900 in the library of the Horticultural Society of New York. Following the main body of the catalog is an extensive list of reference sources to serve as a basis for research and study.

The American Camellia Yearbook 1971

Joseph H. Pyron, Editor. American Camellia Society, Fort Valley, Georgia 31030. 281 pages. Illustrated. (Library)

An annual flower yearbook serves to make a record of that flower and the society that is interested in it. And yet in each yearbook there are articles of perhaps greater interest such as those concerned with the plant itself, changes that are taking place and improvements.

This book has several articles of interest to the plantsman. The snow camellia in Japan, a story of *Camellia rusticana* is interesting as it describes the locale where this plant is found naturally under rather severe winter conditions. This offers considerable prospect for use in hybridization to produce more winter hardy plants.

A report on breeding for winter tolerance is made, of work at the University of North Carolina, Chapel Hill and at Longwood Gardens in Kennett Square, Penn. which points out the different climatic conditions and the influence of this on the growth of the plant and the suitability of certain hybrids.

Another report is of the Winter Hardiness and breeding work at the U.S. Plant Introduction Station at Glenn Dale, Md. including an evaluation of some of the introductions that are being tested.

Other articles tell of the new cultivars recently introduced, of the control of pests, of persons who have influenced the development and spread of interest in the plant, and those of general society interest.

CONRAD B. LINK

Exotic Plant Manual

Alfred Byrd Graf. Published by Roehrs Co., East Rutherford, N.J., 07073, 1970, 840 pages, more than 4,200 illustrations, in color and black and white, $27.50 (Library)

This is a slightly smaller version of the authors pictorial encyclopedia Exotica, but is more comprehensive since it includes cultural and related horticultural and botanical information.

The book begins with a review of geographic origins of the exotic plants that are adapted for use indoors. Alfred Graf has traveled world-wide in his search of new material and brings in his own observations in a casual and interesting manner.

He reviews the cultivation of plants as a part of many civilizations and then discusses plant culture in general. The chapter on propagation is well illustrated showing with text and pictures, propagation by seed and vegetative methods and the reader is able to both read about and see how it is done.

The feature of this book that is its unique quality are the chapters or groups of the pictures of the plants based on a botanical relationship, such as the aroids, bromeliads, ferns and fern-like or palms and palm-like plants which give a clue as to their culture. Chapters are also based on a plant characteristic as colored foliage, vines, blooming plants or fruiting and berried kinds which may suggest uses for such types. Each picture has an identifying symbol or pictogram in the lower right-hand corner that is a guide to the cultural requirements—temperature, soil, moisture, and light. This pictogram code is explained early in the book and on the inside of the back cover so it is readily available. These chapters are followed by the descriptions of the plants, arranged alphabetically according to genus and includes the plant family, origin, culture, and page on which it is identified.

The last chapters are devoted to the use of plants for decoration and indoor landscaping, with excellent illustrations of homes, restaurants, offices, in lobbies, and public buildings.

Indexes of both common and generic names of plants add to the value of it's usability.

The author's wide experience with hundreds of kinds of plants he has seen, his experience in growing and using them and his observation from traveling and collecting gives this book a very special value that makes it useful not only to the plantsman, but to the grower of plants, the decorator, the educator or just the plant hobbyist. It is a reference book that will be needed in the library of any school where horticulture is taught, in horticultural and garden libraries and in general reference libraries. This Exotic Plant Manual is a major contribution to horticultural literature.

CONRAD B. LINK

Gardening in the East

Stanley Schuler, The Macmillan Company, 1969. 407 pages. Illustrated, $9.95.

Gardening in the East actually deals with gardening in the northeastern United States —the eleven states from Maryland to Maine, and the District of Columbia.

The first section of the book covers environmental factors. Of particular interest is the chapter on climate where the climatic elements of each state are reviewed. There are useful tables showing zones of first and last frost and related data. It is difficult however to make generalizations even within a single state. For example, in Maryland the number of frost-free days ranges from 225 to 130 in different parts of the state.

After brief chapters on soil improvement, watering, and mulching practices, winter protection, and plant pests, the remainder of the book is devoted to brief descriptions of plant materials. Hardiness descriptions are keyed to the USDA Plant Hardiness Zone Map. Chapters are devoted to the following: trees, shrubs, hedges, vines and climbers, ground covers, ferns, annuals, perennials and biennials, bulbs, lawns, fruit and nut trees, small fruits, and vegetables. The plant lists appear to be well selected and accurate (although *Tradescantia virginiana* is certainly not a woody plant). The black-and-white photographs show garden settings and landscape plantings, but no individual plants are illustrated in detail.

As an introduction to the climatic conditions of the northeast and to the variety of garden plants which may be grown there, this book should appeal to the beginning gardener as well as to those moving into the area from another part of the country. It is likely that gardeners with experience in the northeast will prefer more specialized references.

ROBERT L. BAKER

Date of Publication: September 22, 1971