Distribution of systemic through the leaf veins.

Systemics, A New Help in Pest Control

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Since Leonardo da Vinci suggested that arsenic be introduced into fruit trees to control pests systemically, man has become increasingly fascinated with the idea. The possibility of allowing the sapstream to move toxicants throughout the plant for the control of pests is an intriguing one. This group of chemicals is referred to commonly as "systemics," and includes certain insecticides, fungicides, nematocides, and a few herbicides.

WHAT ARE SYSTEMICS?

A systemic pesticide is a chemical that is absorbed by the roots, foliage, or other areas of the plant and translocated in the sap to all parts of the living host plant. In turn, pests feeding on the treated host take up the chemical and are killed.

Systemic chemicals are available in a variety of formulations such as liquids, granules, and wettable powders.

Even the modern concept of systemics is really not new. In 1936 A. M. Hurd-Karrer and F. W. Poos in an article in **Science Magazine** revealed that aphids and red spider mites died within a few days when allowed to feed on a nutrient solution containing selenium. This chemical is very toxic to man and animals and should not be used on soils growing food and forage plants.

Plants are also subject to toxicity from selenium. For these reasons its present use is very limited. In addition, selenium has exhibited extended life when incorporated in the soil structure.

Bordeaux mixture and derris (rotenone) are very old chemicals which have also exhibited systemic activity.

HOW DO THEY WORK?

"Uptake," according to D. M. Norris, University of Wisconsin, "involves those phenomena that account for the movement of systemics from the points of application to the soil or

plant into the sites where vascular transport in the phloem or xylem tissues is initiated." Uptake may occur through all portions of the plant. The unique properties of systemics can be more effectively utilized by the plant when the uptake proceeds through the roots. In the case of trees and shrubs, the basal trunk is also included.

Systemics enter the root structure of plants by two methods: passive or active entry. A. S. Crafts from a text **Translocation in Plants** reports:

"Passive entry means that chemicals in the soil solution continue into the root structure via the so-called 'outer' or free spaces within or between the cells."

In 1965 D. M. Norris stated that: "Active entry involves absorption of chemicals through cell walls, adsorption on or absorption through membranes associated with protoplasm, and then subsequent transfer along and through such membranes into vascular tissues (i.e., phloem and xylem)."

The xylem and phloem are composed of elongated cells adapted to the movement of materials through the plant. The xylem provides mechanical support and conducts water, minerals, and undissolved salts upward from the roots through the plant. Xylem tissues are of primary importance to the transfer of systemics within the plant system.

The phloem is the channel through which soluble foods are conducted downward from the leaves through the plant. Ray tissues are bands of cells extending horizontally through both xylem and phloem. These same ray cells are significant in food storage and in the lateral conduction of food and water. They appear to be of major importance in the ingress of systemics. The accompanying diagram may help to clarify the relative positions of these vital plant tissues.

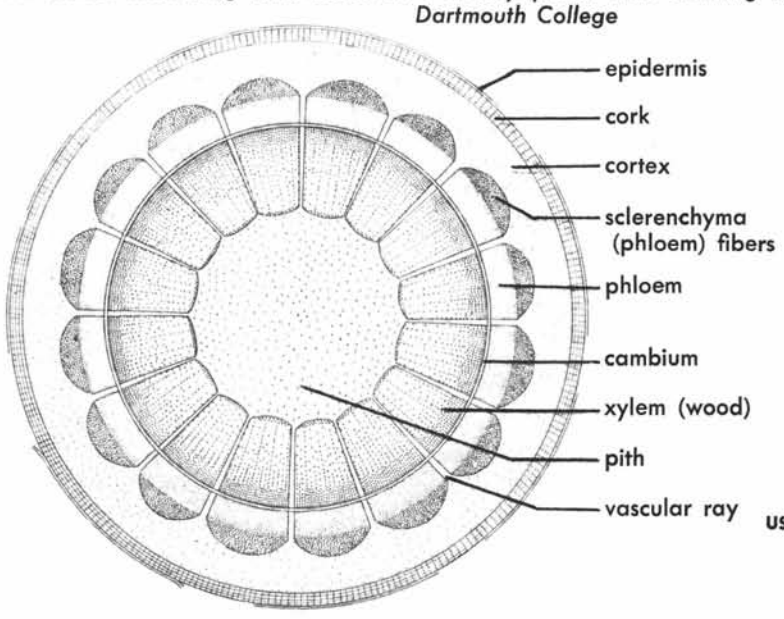
By making use of the soil-root direction of uptake for systemic treatments, we take advantage of the plant's most obvious and important organs of nutrient and water uptake, its root structure. The utilization of the soil as a passageway for systemics into the plant has, however, resulted in problems. Certain systemics such as Phosdrin (melvinphos) have been rapidly broken down. H. T. Reynolds in "Advances in Pest Control Research" (1958), states that heavy clay soils exhibit the tendency to absorb systemic chemicals. In addition, A. D. Hanna and J. Nicol in "Nature" (1955) discuss the problem of leaching, evaporation, and decomposition of chemicals by soil organisms. Generally, soils of high organic content serve to speed up the "breakdown" of chemicals.

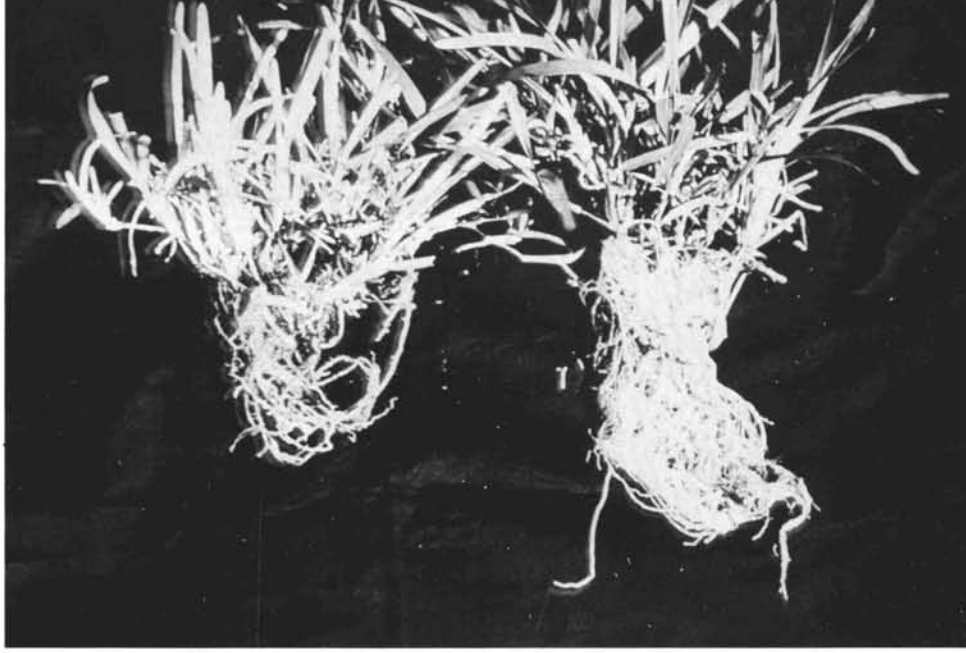
Translocation occurs once the systemic has entered the plant. It is the process by which nutrients, chemicals, and water are moved through the vascular system (phloem and xylem) to all parts of the plant. Present knowledge concerning the transport of foreign chemicals within plants is disturbingly limited—especially in grasses. However, radioactive tracers are being used to some degree for translocation studies. We will know more in the future.

Transpiration greatly influences the direction and rates of movement of systemics in the xylem of trees. Adequate, uniform distribution of systemics within trees and shrubs is still the most limiting factor in the effective use of these types of chemicals. Very little movement downward occurs to the roots from the trunk in trees.

Seasonal growth cycles in plants, especially trees and shrubs, greatly affect the rate of movement of systemics. Application of systemics in January and February in northern climates prove ineffective due to a lack of vascular activity. Growth processes of most plants are

Cross-section illustrating vital tissues of a woody plant. Line drawing by Hannah T. Croasdale, Dartmouth College





Roots of St. Augustine grass, the specimen to the left showing nematode damage, the right showing the response from systemic, Dansanit.

very sluggish at temperatures of about 40°F or below, but increase as temperatures from 70° to 90°F are reached.

HOW ARE THEY USED?

There are three ways in which systemics may be introduced to the plant: soil applications with either granules or a liquid drench, trunk injections, or foliar sprays. Granules are easier to handle and are reasonably safe. They may be used as a broadcast treatment, side dressing, or mixed into the soil. Soil treatments are recommended where underground pests feed on roots. The liquid drench is also a relatively easy way to apply these materials.

Trunk injections or basal trunk banding have been the most effective for trees and shrubs. Foliar sprays on trees are good for rapid response, but they do not have the lasting qualities of the other methods. This is true mainly because the foliage area of the plant does not absorb systemics as readily as the root system. Uniform application of systemic material to the plant is important for faster, more effective distribution throughout the tissues.

Systemics must be used only on plants indicated on the label accompanying the package. Experimental plots established by the uninitiated may be interesting, but may also cause severe injury to plants that are not included on label recommendations. This is due to varied physiologic responses between and among assorted plant species.

WHAT WILL THEY CONTROL?

The golf course superintendent is confronted with a host of pests which harm turf and ornamentals. Generally speaking, present labels of various systemic chemicals include the following types:

Insects: aphids, leaf miners, thrips, leafhoppers, scales, sod webworms, cutworms, lace bugs, whiteflies and mealybugs.

Mites: various species.

Nematodes: stylet, meadow, pin and root lesion.

Diseases: snow mold, Pythium blight, dollarspot, stripe smut of bluegrass, Pucinia rust of bluegrass and powdery mildew.

Sucking insects such as aphis and leafhoppers are quite easily controlled. Scale insects such as San Jose scale, which inhabit the upper portions of trees, are more difficult. This occurs when large populations build up on plant surfaces. Chewing insects, if they are feeding on roots, can be easily controlled with soil applications.

WHERE CAN I USE THEM?

Systemic pesticides are now being developed for control of an ever increasing number of pests. However, present recommendations for turf are disturbingly scanty. Systemic insecticides thus far have practically ignored turf in label recommendations. In most cases the species of turf to treat is not specified. It is quite evident that research has not kept pace in systemic chemical resignations for turfgrass.

In reading the following, trade names are used for illustration purposes only and are not intended as recommendations or endorsement.

Zectran, a relatively new carbamate systemic, has been shown to be beneficial for control of sod webworms, cutworms, snails and slugs. Two granular systemics called Thimet (phorate) and Dasanit (fensulfothion), are listed for certain nematodes. A prominent pest in bermudagrass known as the Rhodes grass scale is listed as being controlled by Meta-Systox-R (oxydemetonmethyl).

Systemic fungicides are just beginning to come into view, and great developments may lie ahead. A new product called Benlate (DuPont 1991) produced good control of **Selerotinia** dollarspot and stripe smut of bluegrass. This new product was also listed as a benefit in controlling powdery mildew in ornamental trees and shrubs in addition to soil-borne diseases such as **Rhizoctonia, Fusarium, Verticillum** and **Botrytis**.

Tipula sp. snow mold and **Pythium sp.** in winter overseeded turf are listed for control with Demosan (chlorneb). Finally, a chemical compound known as Plantvax has shown control of **Pucinia** bluegrass rust. Of the grasses, bermudagrass, bents and bluegrasses have been specifically mentioned for fungicide systemics.

Some of the ornamental plants presently covered for use with various insecticide and fungicide systemics include roses, birch, boxwood and oak in the broadleaf category. Evergreens include cedar, pine, fir, and arborvitae. Certain flowering plants may also be protected by systemics, including perennials such as gladiolus, iris, and carnations. Some annuals represented are azaleas, camellias, dahlias, chrysanthemums, and daffodils.

HOW LONG DO THEY LAST?

The longevity of any chemical is an important factor in its effectiveness. The constant variables such as soil types, leaching, heat, moisture, light intensity, and wind have a definite bearing on the residual life of all chemicals.

The systemic persistence of chemical action within a plant is influenced by extended uptake. White pines 20 to 30 feet tall when injected with a systemic known as Chipman R-6199, and using 16 grams per tree, controlled sawflies for two years after treatment. Reports also indicate that this same chemical was good for control of elm bark beetle in elms for two growing seasons. H. Eidman in 1963 obtained control of insects on pines and birch for one year using 5 per cent Meta-Systox-R.

The dosage of a systemic when injected into a tree also influences the persistence of chemical action in that plant. D. M. Norris and H. C. Coppel in the **Journal of Economic Entomology,** (1961), found that eight grams of Bidrin injected into white pines gave 75 per cent mortality of sawflies up to one year after treatment. Four grams of the same chemical failed to give such control. Successful demonstrations as these indicate that longer periods of control are possible. This does not hold true for all systemics, however, since they vary greatly in chemical composition.

Some tree systemics exhibit such great persistence that at the time of leaf fall the surrounding environment is contaminated by leaves from previous chemical treatments. Systemics of this type cannot be used commercially.

WILL THEY HURT THE GOOD BUGS?

It has been said by some that "the only good bug is a dead bug." This rather bold statement is far from being true. Ninety-eight per cent of all known insects are either predators or parasites of one another. Most conventional insecticides such as DDT have delivered a terrible blow to beneficial insect populations. These "friends" play a vital role in the balance of nature.

It is important not to contaminate the environment with undesirable chemical residues. This is where systemics shine! Because a systemic is confined inside the plant, people, domestic animals, and beneficial insects do not come into direct contact with it.

Also, systemics are not lost through external weathering action. They are incorporated within the plant sapstream and are well barricaded by the exterior areas of the plant.

WHAT SYSTEMICS ARE AVAILABLE?

Thus far, most systemic chemicals have been quite poisonous and have required extra care in handling. New label registrations and a variety of new systemic materials are coming on the market this year. They cover a wide range of ornamentals and turf with broad spectrum control for a great variety of insects and diseases.

Following is a list of systemics presently in use:

INSECTICIDES

Baygon (propoxur)
Bidrin
Cygon (dimethoate)
Dasanit (fensulfothion)
Di-Syston (disulfoton)
Meta-Systox-R (oxydemetonmethyl)
Phosphamidon (dimecron)
Systox (demeton)
Thimet (phorate)
Zectran

FUNGICIDES

Benlate (DuPont 1991)
Demosan (chloroneb)
Plantvax (F-461)
Vitavax (D-735)

SUMMARY

All chemicals have advantages and disadvantages, depending on a particular situation. None of them are sure fire. Although the initial cost of systemics seems high, their use can be justified when they give control over an extended period of time. This will result in dollar savings for labor and material.

Price ranges of systemics generally vary from $20 to $25 a gallon for liquids and 25 to 30 cents a pound for granules. This is somewhat misleading, however, because the rates recommended for each product vary.

Systemics are quite easy to apply with many formulations to choose from. Extra care should be taken during application to insure proper rates and coverage. This in turn enables more effective absorption and distribution within the plant tissues.

Phytoxicity can result from excessive dosages. When leaves transpire, these high concentrations of chemical salts accumulate and marginal leaf burns appear. The idea that "if one ounce is good, three is better," is to be avoided when using systemics.

Soil application of systemics exhibit reduced effectiveness occasionally. Hydrolysis from alkaline waters and absorption onto muck-type soil particles contribute to this. Once the systemic has been absorbed by the plant, however, it is protected from "weathering off." This provides long-lasting residual control.

Systemics control a fairly broad range of insects and diseases. In the case of trees, pests which attack the leaves and young twigs are readily killed because most of the systemics concentrate in these areas. Pests which attack the trunk and vascular tissues in trees and shrubs are less vulnerable. The problem here is one of keeping the chemical in the tissue long enough to do the job. Frequently it moves to the leaves too rapidly.

Some systemic materials take longer to actuate with the plant system because of insolubility. This can be a benefit, however, because chemicals of this nature are not readily lost by rapid translocation throughout the plant system.

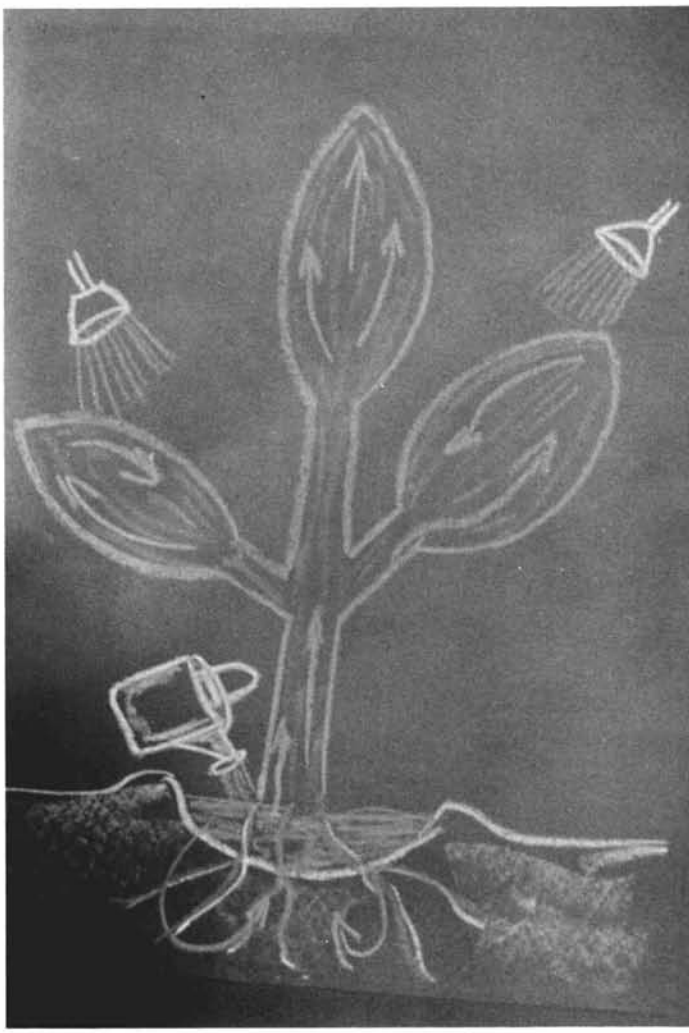
Systemics will occupy an important area of pest control in the future. Such new developments as impregnation of systemics onto particles of fertilizer and soil amendments is already a reality.

We may be able to establish control programs that will include a variety of situations on the golf course. Think of what it would mean if with a single application of a systemic we might obtain control over such pests as frit fly, **Pythium** blight and Dutch elm disease.

Such built in protection would save many dollars in pest control and labor. The superintendent would then have additional time to devote to other turf management requirements. His program would move that much farther ahead.

"The future always holds something for the man who keeps his faith in it."

H. L. Hollis



Uptake from both soil and foliar applications of systemics.