The Effects of Phenoxy Herbicides on the Physiology and Survival of Turfgrasses

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Injury to sensitive turfgrasses by some of the more prominent herbicides has received considerable interest in recent years. Two such susceptible species are Colonial bentgrass (*Agrostis tenuis*) and creeping bentgrass (*Agrostis palustris*). These species are especially sensitive to the phenoxy herbicide 2-(2, 4, 5-trichlorophenoxy) propionic acid (silvex). Furthermore, silvex is gaining increased acceptance in turf weed control.

Bentgrasses growing in cooler habitats may exhibit a fair degree of tolerance to herbicidal rates of silvex. However, silvex treated bentgrasses growing under high temperatures are often fatally injured. Since bentgrasses are becoming more widely used in golf greens and fairways throughout warmer regions, it has become necessary to re-evaluate weed control programs which include the use of silvex or other phenoxy herbicides. To exclude silvex would be a waste of scientific achievement since this herbicide is safe on most turfgrasses and gives excellent control of many broadleaf weeds normally tolerant to most other phenoxy compounds.

In just what form phenoxy herbicidal injury manifests itself in turfgrasses has received little attention in past years. A common belief is that injury occurs simply as foliage burn which, in severe cases, results in plant death. Recent investigations have revealed that phenoxy herbicides may cause disturbances to internal plant functions which greatly weaken a plant. This type of injury often goes unnoticed but may destroy natural plant tolerances to environmental stresses and predators which eventually receive the blame if the plant dies.

Certain highly susceptible turf species have tolerated phenoxy treatments at particular times of the year. This suggests that naturally occurring environmental conditions may exist which allow sensitive turfgrasses to be safely treated with weed control rates of silvex.

With these interests in mind, studies were conducted using several rates of silvex to determine its effects on the physiology, morphology, and anatomy of Colonial and creeping bentgrasses growing under various environmental influences. A primary consideration was to determine if there is a time of the year in which herbicidal rates of silvex can be applied with little danger of injury to bentgrasses. A special effort was made to explain the type, extent, and form of tissue disorders induced in the roots of phenoxy treated turfgrasses. Comparisons were made also between the effects of silvex on turfgrasses with those of 2, 4-dichlorophenoxyacetic acid (2, 4-D) and 4-(2, 4-dichlorophenoxy) butyric acid (4-(2, 4-DB)).

Influence of Environmental Factors on the Effects of Silvex on Bentgrass

Seasonal temperature responses:

Silvex treatments of ½, 1, 1½ or 3-pounds active per acre applied during early- to mid-spring on a mature Colonial bentgrass turf in northern New Jersey caused no serious injury. These spring treatments still provided good broadleaf weed control. Applications during this time appear to be safer after the grass has started its flush of new growth and is growing rapidly.

Often foliage showing little or no response to treatment give no indication of the severe injury occurring to the roots. Occasional reductions in root length, density, food reserves, and dry matter accumulation may occur from most any weed control rate of silvex applied during the spring. Fortunately, this injury appears to reach less critical proportions when bentgrass is growing under cool temperatures and short photoperiods from early- to mid-spring. However, treatments of 1-pound or more per acre applied during late spring may cause moderate to severe injury to bentgrass.

If temperatures increase after silvex applications, injury to top and root growth of bentgrass tends to increase. Treatments during warm weather and summer are generally undesirable, especially if bentgrass is in an active stage of growth. The obvious responses of foliage to silvex during high temperatures and long photoperiods, especially under droughty conditions, appear suddenly as leaf burn. This type of injury which resembles contact chemical burning may result in reducing the amount of phenoxy absorbed by the plant. Such environmental stresses reduce plant activity and result in plants that are less receptive to uptake and translocation of phenoxys. However, contact injury to weakened bentgrass growing under hot, dry conditions offers greater possibility for kill of the plant. The crowns of the plants are highly vulnerable to chemical contact which under high temperatures cause fatal disruption of these tissues and ultimately plant death.

In general, treatments applied during late summer and early fall appear to have very severe and even fatal effects on bentgrass. Treatments during mid- to late-fall are more risky than assumed previously. The explanation for this appears to be herbicidal interference with build-up of food reserves in preparation for winter dormancy.

Effects of silvex rates: Under high temperatures silvex treatments of 1 and 1½-pounds active per acre generally cause the most severe reduction of root growth and appear to be most detrimental. The 3-pound rate does not always give as much kill; it tends to cause more contact burning and give less total effect. Under cool temperatures bentgrass appears to be injured the most from treatments of 1½ and 3-pounds per acre.

Influence of pH: Untreated bentgrass plants grown in nutrient solutions of pH 4.8 appeared to grow better than those in cultures at pH 7.0. However, with plants receiving silvex treatments injury was greater at the low pH.

Effects of moisture level: Bentgrass conditioned to low available moisture appears to tolerate detrimental rates of silvex better than when growing under higher moisture levels. However, when moisture is depleted silvex treatments tend to hasten bentgrass desiccation.

Effects of Phenoxy Herbicides on Four Turf Species

Turfgrasses treated at several ages of seedling growth with 2, 4-D, silvex and 4-(2, 4-DB) showed greater tolerance with increasing age. Seedlings of Colonial bentgrass, Merion Kentucky bluegrass, creeping red fescue, and common bermudagrass treated at 8, 10, 14 and 18 weeks of age with the three phenoxy herbicides usually showed foliage injury. Generally, injury correlated with the rate of phenoxy application and with the type of root and shoot growth of the species.

Seedling responses at 6-weeks of age: At 6-weeks bentgrass seedlings were fatally injured and bluegrass was severely injured by all rates of the three phenoxy herbicides. The rapidly developing fescue and bermudagrass seedlings showed severe injury only from the rates of 1-pound and higher.

Seedling responses at 10-weeks of age: Bentgrass was severely injured from 1, 1½ and 3-pounds of 2, 4-D and 4-(2, 4-DB) and fatally injured from all rates of silvex. The 1-pound rate of 2, 4-D and silvex and 1, 1½ and 3-pounds of 4-(2, 4-DB) caused very severe or fatal injury to bluegrass. Fescue continued to exhibit considerable tolerance being severely injured only from the 1-pound rate. Bermudagrass showed a fair overall degree of tolerance; it was severely injured from the 1-pound rate and higher, particularly from silvex.

Seedling responses at 14-weeks of

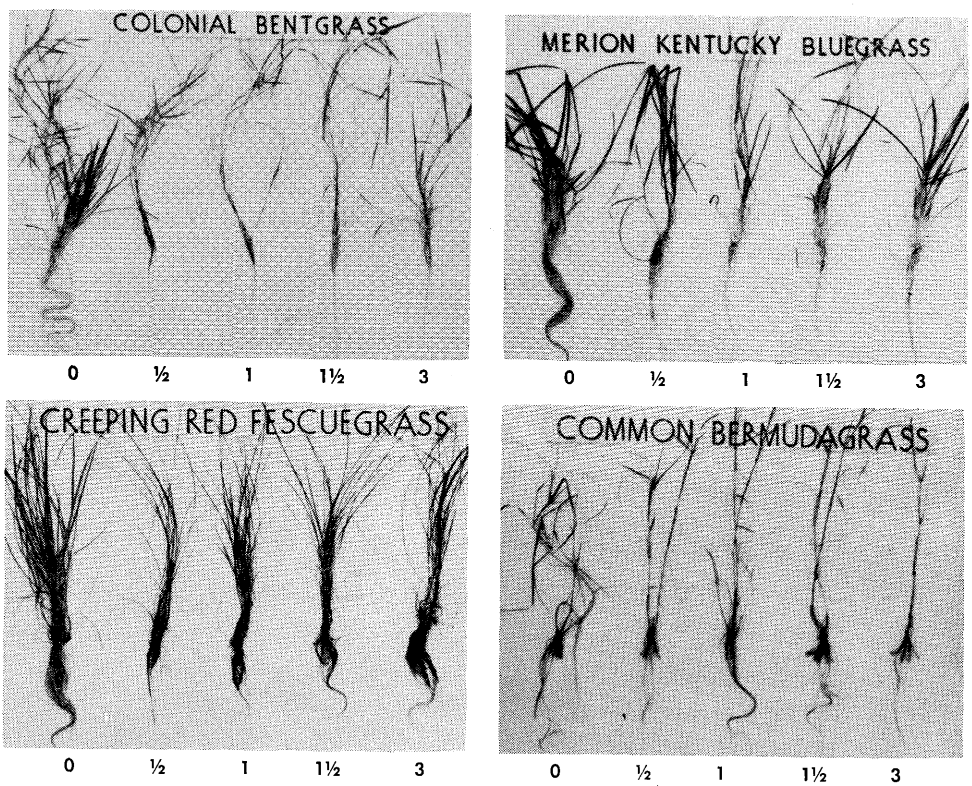

Fig. 1. Root and shoot growth of Colonial bentgrass, Merion Kentucky bluegrass, creeping red fescue, and common bermudagrass at 18-weeks of age 20 days after treatment with silvex. Figures under each plant indicate pounds per acre.

age: Although 14-week-old seedlings of bentgrass and bluegrass were still highly sensitive to silvex, they showed considerable tolerance to 2, 4-D and 4-(2, 4-DB). Fescue and bermudagrass declined rapidly in general susceptibility. The higher phenoxy rates of 1 through 3-pounds per acre still caused moderately severe injury.

Seedling responses at 18-weeks of age: Bentgrass and bluegrass showed good tolerance at 18-weeks of age, especially to 2, 4-D and 4-(2, 4-DB) (Fig. 1). Although fescue declined in growth rate it still exhibited very good tolerance to the three phenoxys. Bermudagrass seedlings continued to grow rapidly and gain tolerance.

General seedling response: Bluegrass seedlings usually showed more tolerance to the phenoxys than did bentgrass at corresponding ages. Fescue generally appeared less susceptible to phenoxy injury at the four ages of seedling growth than did bermudagrass. However, both exhibited much greater tolerance than either bentgrass or bluegrass seedlings.

Silvex injury was usually more severe than 2, 4-D. Generally 4-(2, 4-DB) caused mild injury. The 1-pound rate generally caused more severe plant injury than higher rates. This suggests that lower concentrations may be absorbed and translocated before foliage burn prevents further chemical uptake. Higher concentrations usually cause rapid burning of foliage which greatly reduces the amount of chemical absorbed.

Phenoxy Induced Tissue Abnormalities

Untreated root tip: Normal root cells in an untreated root tip of Colonial bentgrass (Fig. 2) may appear well defined, orderly and uniformly arranged. Various stelar elements (photo A and B) such as the pericycle (the cylinder of cells in the outer stelar region exhibiting a nucleus), the xylem, and phloem generally lack prominence.

Typical meristematic cells can be seen to rapidly differentiate into column type rows of rectangular shaped epidermal and cortical cells (photo C and D). The general absence of lateral roots and root hairs is also typical of this region.

Silvex affected root tip: Those who have observed for the first time the microscopic effects that a phenoxy herbicide may have on the roots of a turfgrass are often astounded (Fig. 3). This is understandable since these tissue abnormalities are not normally visible to the naked eye. Tissue abnormalities induced in bentgrass roots were observed as contributing to the death of the plant. These tissue disorders and cellular disruptions appear to obstruct normal nutrient passage through conductive tissues and actually destroy the function of many cells. Accelerated and prolific formations of roots, root hairs, and cells could also occur at the expense of food reserves.

Abnormal formations of roots and root hairs are highly prevalent in the region of the root tip following a phenoxy treatment. Some cortical cells may swell to at least 24 times the size of corresponding normal cells. The pericycle cells, as well as their nucleus, often become very large and prominent (photo B). Lateral root formations (photo C) may occur abnormally close to the root tip. Massed proliferations of the pericycle (photo D) and massed lateral root formations (photo E), with accompanying swollen cortical cells, are often conspicuous. These massed lateral root formations are usually more prevalent in the region where the pericycle is proliferating.

Similar tissue abnormalities were

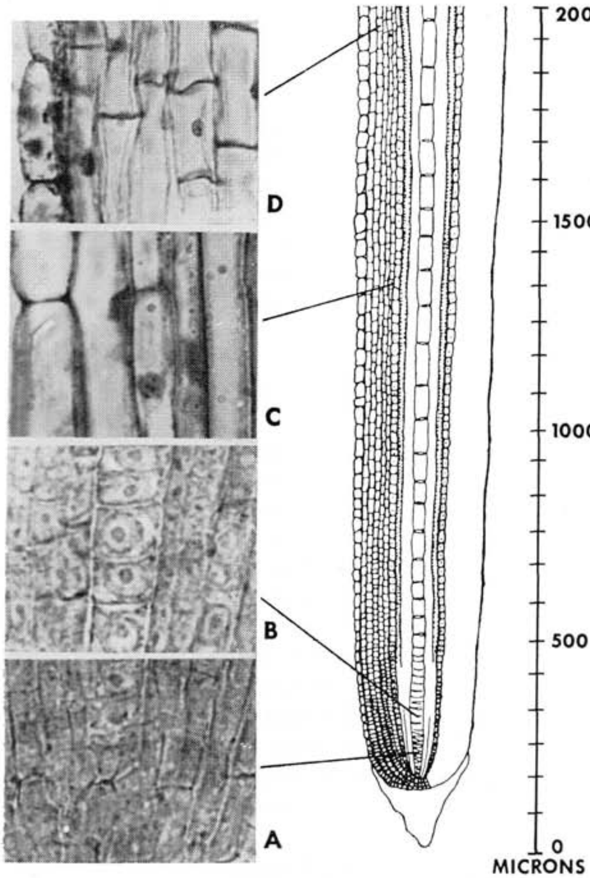

Fig. 2. A median longitudinal section of the apical 2000 microns of a normal Colonial bentgrass root. (Camera lucida drawing as 100X and photomicrographs as 1290X).

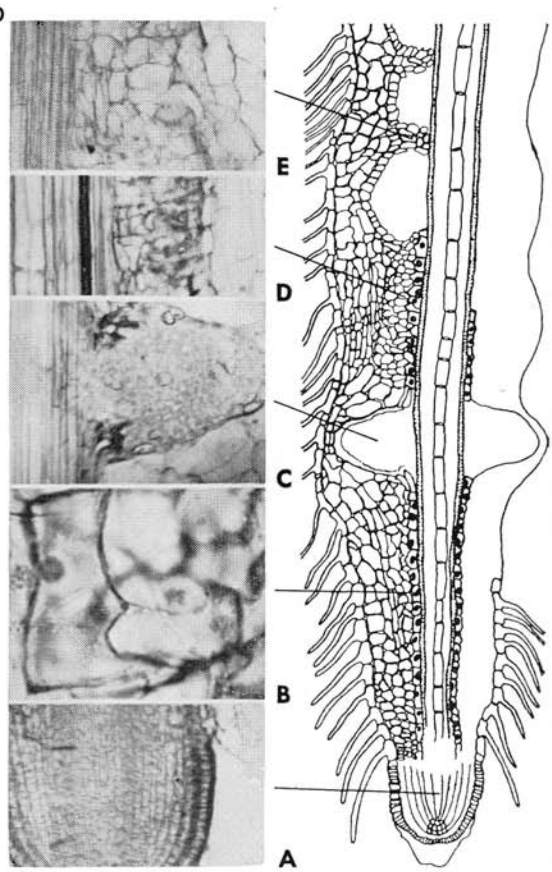

Fig. 3. A median longitudinal section of the apical 2000 microns of a silvex affected Colonial bentgrass root. (Camera lucida at 100X, photomicrographs A. C, D, E at 300X and B at 1290X).

observed to be produced by 2, 4-D, silvex, and 4-(2, 4-DB) in Colonial and creeping bentgrasses, Merion Kentucky bluegrass, creeping red fescue, and common bermudagrass.

SUMMARY

The effects of phenoxy herbicides on turfgrasses may be limitation of root system, depletion of root food reserves and actual tissue disruptions which result in either plant death or making the roots readily accessible to plant diseases. Any of these factors offer a great threat to the survival of the plant particularly when accompanied by medium to high temperatures.

Safety of sensitive turf species to phenoxy herbicides may be increased by using lower concentrations applied during cooler growing seasons. The safest period for treating bentgrass appears to be from early- to mid-spring.

Potassium - Neglected Nutrient

By **Dr. H. E. Hampton***

Potassium is one of the several chemical elements which are essential for plant growth; it is needed in rather large amounts by plants, especially the grasses.

All growing portions of plants, both tops and roots, are rich in the element. Potassium seems especially abundant in the cells of new roots and young leaves. It is one of the more mobile nutrient elements and is apparently withdrawn from older tissues of the plant and transferred to regions of new growth. As plants approach maturity, it has been found that potassium can be translocated into the soil.

Of all the major nutrients, potassium seems to be the only one that does not become a constituent of plant compounds. Its primary role seems to be that of a catalyst — a substance which accelerates a chemical reaction or enables it to go on but does not enter into the products of the reaction. An Australian researcher working with perennial ryegrass found that potassium occurs entirely as soluble, ionic potassium in cell sap and protoplasm. Other workers have found the potassium contained in plants to be readily soluble in water. It appears that if the potassium in plants is combined at all with the protoplasm, it is easily dissociated from it.

The loss of the plant's power to synthesize carbohydrate in the absence of potassium has been reported in several papers. It seems that potassium is essential for the process of photosynthesis in which sugars are manufactured. Potassium has been found essential for the condensation of the simple sugars into more complex carboydrates such as starches and the celluloses and for the formation of lignin, the principal compound of woody plants. Several workers have reported evidence that potassium is necessary for the translocation of the carbohydrates from one part of the plant to another.

Lignin Content

The lignin contained in plants contributes to the strength of stems and

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