MAY 1965

USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association

FLOOD DAMAGE IN OREGON

The 11th green at Illahe Hills Country Club, Salem, Ore., lies in ruin after severe flooding of the Willamette River last December. See story page 12.

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

By **Lloyd M. Callahan,** Assistant Professor, The University of Tennessee, and **Ralph E. Engel,** Turf Specialist, Rutgers

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

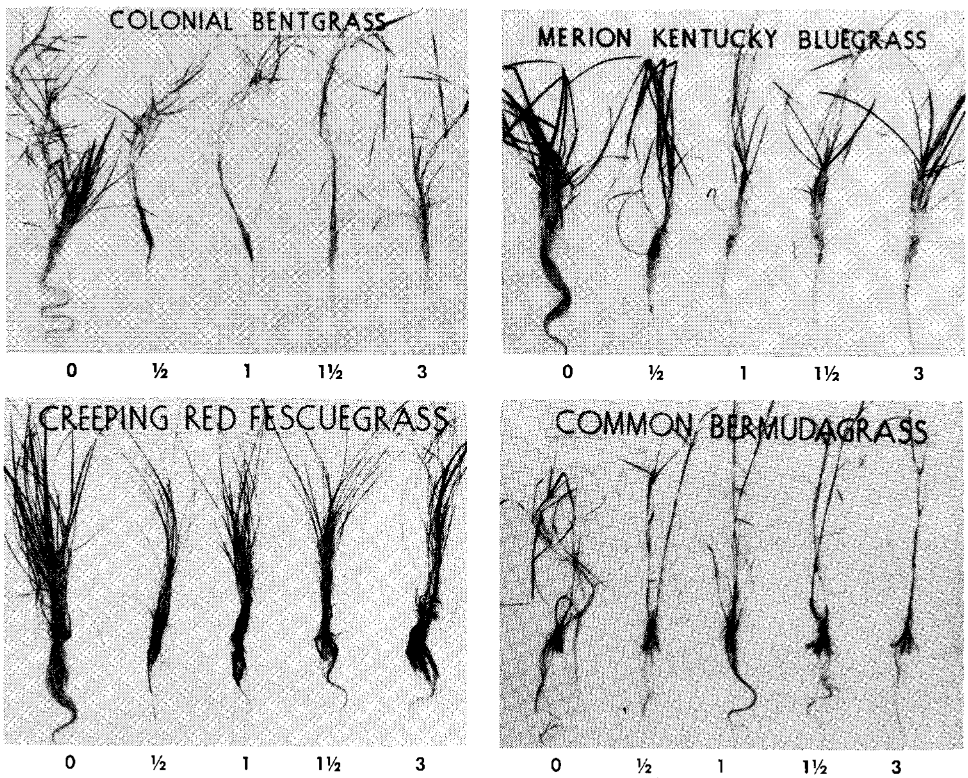

Fig. 1. Root and shoot growth of Colonial bentgrass, Merion Kentucky bluegrass, creeping red fescue, and common bermudagrass at 18-weeks of age 20 days after treatment with silvex. Figures under each plant indicate pounds per acre.

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 dis-

PUTTING GREEN CONSTRUCTION ASSISTANCE

Greens constructed according to procedures outlined by the USGA Green Section must have a seedbed that conforms to a rather narrow specified range of physical qualities. The tests for determining the mixture of your materials which will most nearly meet these requirements are available through the Green Section. Cost of the analysis is $100. Contact any Green Section office for further details. (*See inside front cover*).

orders 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

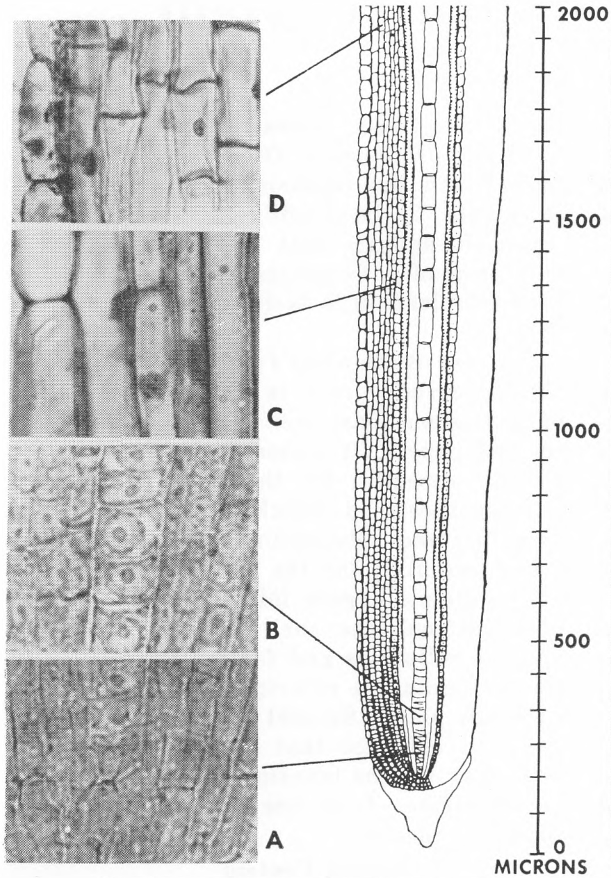

Fig. 2. A median longitudinal section of the apical 2000 microns of a normal Colonial bentgrass root. (Camera lucida drawing as 100X and photomicrographs as 1290X).

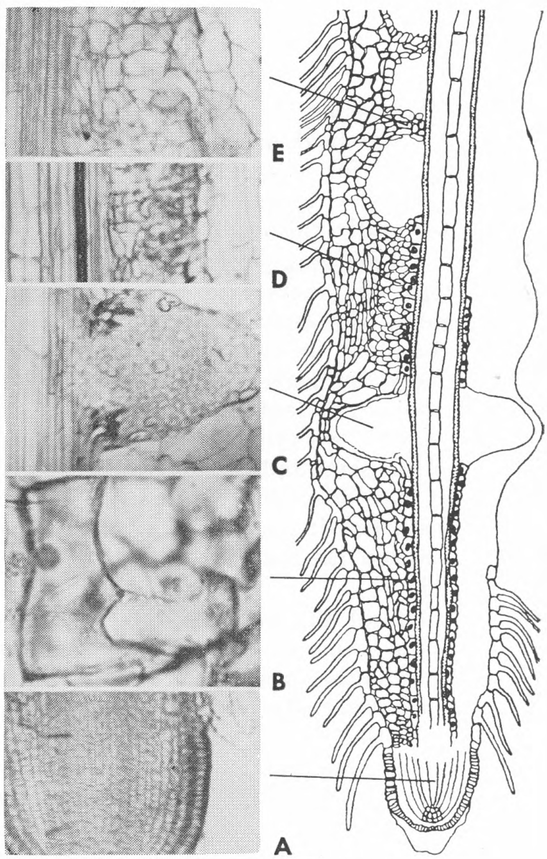

Fig. 3. A median longitudinal section of the apical 2000 microns of a silvex affected Colonial bentgrass root. (Camera lucida at 100X, photomicrographs A. C, D, E at 300X and B at 1290X).

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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also the leaves. It has been reported that potassium significantly affects the lignin content of plant parts. The highest lignin content was found in plants of the grass family when the plants were supplied with medium amounts of potassium. Both deficient and excessive supplies resulted in lower lignin contents.

Potassium is considered to play a role in the synthesis of plant proteins. It is believed by a number of authors to be essential for the manufacture of the protein in plant cells. A deficiency of potassium has been found to result in significantly higher amounts of both amino nitrogen and nitrate nitrogen in the cell sap at the expense of protein.

Several studies have shown rather conclusively that an adequate potassium supply is necessary for normal development of the growing apexes of plants, especially the grasses. Not only will the above-ground parts show abnormal growth but root growth and extension is curtailed as well.

But what has been said about the role of potassium is just so much "book learning" to the golf course superintendent. What he wants to know is how potassium affects the turf on a golf course.

It has been said many times, and often not so humorously, that it would be a much easier job to grow grass on a golf course if it were not for the golfers. This is simply another way of saying that foot traffic and cart traffic and swinging golf clubs are hard on turf. We pointed out earlier the essential nature of potassium on the formation of complex carbohydrates and lignins and it was stated further that these compounds, especially lignin, contribute strength to stems and leaves. Turf plants deficient in potassium are soft and lush, the leaves are lacking in turgor, and the blades are neither erect enough nor stiff enough to present a desirable putting surface. The leaves are easily bruised by traffic. The correct ratio of potassium to other nutrients, particularly nitrogen, will do much to harden and stiffen the turf.

The "Health Nutrient"

Potassium has been referred to as the "health nutrient." It is generally accepted that potassium - deficient plants are more subject to certain diseases. The regular clipping of turf, especially on putting greens, prevents the plant from maturing and thereby increases the susceptibility of the plants to disease. Several studies have indicated that leaf spot diseases of turfgrasses. *Helminthosporium* spp.

especially, are more prevalent when the supply of potassium is limited. Other diseases of turf may be similarly affected by potassium. The influence is due in part to the soft, easily-crushed leaves of potassium-deficient plants which enable the pathogens to gain entrance, and in part to the concentration of sugars and nitrates in the leaves which makes more favorable media for the development of the organisms. This does not mean that applications of potassium constitute a specific cure for diseases. If it is found, however, that a disease persists in spite of regular use of fungicides, it would be wise to check the potassium status of the soil. Any practice which will promote the vigor of the plants will help combat disease.

Both phosphorus and potassium fertilization have been reported to increase the winter-hardiness of turfgrasses. The effect has been attributed to the increased concentration of dissolved substances, largely soluble carbohydrates, in the cell sap. The fact that potassium increases the reserve of stored carbohydrates in the roots is thought also to make perennials more cold tolerant.

In an experiment conducted at Iowa State, it was found that Kentucky bluegrass which was supplied relatively low nitrogen and phosphorus and high potassium withstood hot weather better than bluegrass supplied with either high nitrogen, phosphorus, and potassium or high nitrogen and phosphorus and low potassium.

The practice of applying nitrogen alone during the summer months is likely to induce a nitrogen to potassium imbalance resulting in greater heat damage to the turf. Many superintendents wisely make a practice of reducing the amount of nitrogen applied during the hot months to about half the amount they apply during the same period of time in the cooler spring months. Some withold nitrogen entirely during the hot months, especially on bent greens. If adequate potassium has been applied in the fall and spring, a summer application of potassium fertilizer may not be needed. In case a shortage of potassium becomes apparent, however, it might be wise to apply a light application of potassium fertilizer in the hot months.

Turf Density

A common problem in the management of turfgrasses is the maintenance of a good stand, often referred to as turf density. Although much of the loss in density is due to winterkilling, injuries associated with high temperatures and the weakening of turf by disease also cause many plants to die. Potassium deficiencies aggravate all of the above. The growth and extension of roots which are promoted by potassium are particularly important in keeping a cover of healthy, vigorous turf. The importance of potassium in helping to maintain the density of turf should be emphasized but the need for potassium fertilization is often overlooked.

Potassium occurs in several forms in the soil. By far the greatest portion of it is present as a constituent of the minerals and the organic matter composing the solid portion of the soil. Only a relatively small portion of the potassium occurs in soluble, available forms. Potassium is taken up through the roots of plants as the potassium ion which occurs in the soil solution and also attracted to the clay particles. Either of these can be absorbed by plants.

Plant species vary considerably in their potassium needs. A review of the literature seems to indicate that the potassium requirements of turf grasses are intermediate to high as compared to plants as a whole. At least the turf grasses are generally benefited by potassium fertilization.

Some soils are well supplied with natural potassium whereas many others are deficient. Sands and sandy loams are nearly all naturally lacking in potassium. The finer-textured soils usually but not always contain a good supply of the nutrient.

Inasmuch as fairways and tees are usually constructed of the soil occurring locally, potassium may be lacking or in adequate supply depending upon the nature of the soil. The soil mixture used to construct putting greens contains more sand and potassium deficiencies commonly occur. This is especially true if the putting greens have been constructed according to USGA Green Section specifications. The potassium problem under putting greens is aggravated by the practice of removing the grass clippings.

The removal results in accelerated exhaustion of several plant nutrients including potassium unless the nutrients are regularly replaced. It has been shown that the removal of large amounts of herbage can reduce potassium from an apparently high to a low level in one season bringing about problems associated with potassium deficiency.

Much has been written about "nutrient balance," which is to say that an over-supply of one nutrient will bring about deficiencies of one or more other nutrients. Large applications of lime, for example, have been known to induce shortages of phosphorus and potassium and often magnesium. The trend toward the use of nitrogen fertilizers alone on nitrogen and phosphorus fertilizers has resulted in deficiencies of potassium. On the other hand, too much potassium may induce deficiencies of calcium and magnesium.

Signs of Deficiencies

Deficiencies of potassium may be indicated in several ways. The specific symptom depends upon the species or possibly the group of plants and to an extent upon the available supply of other nutrient elements. Signs of potassium starvation are often seen as premature dying of the leaves when nitrogen and phosphorus fertilizers are applied in high amounts relative to the potassium. When nitrogen and potassium are simultaneously in short supply, the plants tend to be stunted, their leaves small and somewhat ash-gray in color. Premature death often occurs, starting at the tips and along the margins of the leaves. Large supplies of nitrogen relative to potassium, on the other hand, result in the development of large leaves which are watery and lush. Actually clear-cut visible symptoms of potassium deficiency in turf grasses are not common. The growth and health of turfgrasses may be impaired due to a potassium shortage although there are no visible signs. The result is an overall loss of vigor in the plants. The insidious nature of "hidden hunger," especially that induced by a shortage of potassium, has been mentioned by several writers.

Soil and tissue tests are helpful tools in the diagnosis of plant needs. By chemical techniques we hope to ascertain the "hidden hunger" that is not visibly evident. Recommended procedures for soil and tissue analyses are not entirely infallible, however, and interpretations of test results are not easy. This is particularly true in the case of potassium. For example, many people have full confidence in plant tissue tests for potassium although it is known that in nitrogen deficient plants potassium may accumulate whereas with adequate nitrogen potassium may be utilized so rapidly that it appears deficient.

By the foregoing statements it is not intended to imply that soil or tissue testing are not helpful tools. They must be conducted and interpreted by a well-trained, experienced person, however, who knows or has been informed of past treatments and plant behavior. At several of the Land Grant Universities the personnel concerned with soil and tissue testing are cooperating closely with the turf specialists.

Most golf course superintendents use liberal amounts of nitrogen fertilizer. Many make applications of phosphorus and potassium alone or with nitrogen once or perhaps twice a year. On some courses, only nitrogen and phosphorus are applied. There is evidence that enough phosphorus fertilizers are being used on most courses to satisfy the needs of the turf. There is about as much evidence to indicate that the amount of potassium which is being applied does not adequately supply the grass plants throughout the year. Either an insufficient amount of potassium fertilizer is being put on or the amount being applied could be better distributed through the year. Such a statement may be made because plants are known to take up more potassium then they need if the soil supply is high in potassium and a fall or winter application of potassium can be exhausted before summer.

The variations in soil characteristics and the differences in plant species mean that there is no such thing as a balanced fertilizer. Amounts of N, P, and K which seem adequate or "balanced" for a certain turfgrass on one soil are likely to prove inadequate on another soil or for the desirable growth of another turfgrass.

The need for better balance between nitrogen and potassium is currently receiving more attention. Relative amounts of nitrogen and potassium which appear to result in the production of desirable turf in the cooler spring months usually do not work out so well in the hot months. This is not to say that nitrogen is not needed during the summer; it does appear, however, that more potassium in relation to the nitrogen is needed during summer especially on bermuda greens.

Muriate of Potash

Potassium is most commonly applied as muriate of potash. In areas such as Florida or the Pacific Northwest where sulfur is often deficient sulfate of potash is recommended. There has been little evidence of a shortage of sulfur in the soils of the Southwest. A few other potassium materials are used in parts of the country where such materials are cheaper than muriate of potash. At the present time nearly all of the muriate of potash fertilizer used in the Southwest is mined near Carlsbad, N.M.

Most of the mixed fertilizers on the market contain potassium as well as nitrogen and phosphorus although a few contain only nitrogen and phosphorus. All of our fertilizers having ratios of 1-1-1, 2-1-1, 3-1-2 and the like contain potassium. They are called complete fertilizers.

The amount of potassium in a fertilizer is expressed as per cent potassium oxide, usually referred to as potash. None of our potassium fertilizer materials or mixed goods actually contains potassium oxide. Any potassium compound in the fertilizer which is soluble in water is determined chemically and calculated as per cent K_2O (potassium oxide). It is not necessary that any potassium oxide be present in the fertilizer. In muriate of potash, the most common potassium material, most of the potassium occurs as the chloride but there may be a very small amount of potassium sulfate present. Both the chloride or the sulfate forms of potassium are suitable as sources of potassium.

Fertilizer recommendations are usually given in pounds of plant food per acre although recommendations for lawns, putting greens and other small-sized areas are often given in pounds per 1,000 square feet. A recommendation of 120-80-80, for example, calls for sufficient fertilizer to supply nitrogen equivalent to 120 pounds of N, to supply phosphorus equivalent to 80 pounds of P_2O_5, and to supply potassium equivalent to 80 pounds of K_2O per acre. The fertilizer recommendation is taken to mean the annual amount unless otherwise stated and all of the plant food may not be put out in one application.

In order to convert a recommendation in pounds per acre to pounds per 1,000 square feet, one simply needs to divide each number of the former by 43. To the nearest whole number then, the recommendation of 120-80-80 would become 3-2-2 pounds of N, P_2O_5 and K_2O respectively per 1,000 square feet. This means that an amount of fertilizer equivalent to 3 pounds of N, 2 pounds of P_2O_5, and 2 pounds of K_2O should be applied to each 1,000 square feet.

The amount of potassium which will produce healthy, vigorous turf depends upon several factors or conditions. It is not possible to give a specific amount which will fit all soils and all turfgrasses. Recommendations have ranged from one to as much as four pounds of equivalent K_2O per 1,000 square feet annually. Frequently all of the potassium is applied in the fall or sometimes all is applied in the spring. Some superintendents apply part of the potassium in the fall and the remainder in the spring. Most commonly all of the phosphorus and a part of the nitrogen are applied with the potassium.

Applying Potassium

Although recommendations based on sound soil tests are more reliable, the following may be helpful in arriving at the amounts of potassium to apply:

1. Pounds of equivalent K_2O annually per 1,000 square feet on fairways and tees—
   - a. Clay or clay loam soils .. 1 pound
   - b. Loams or silt loams .... 1 pound
   - c. Sands and sand loams .. 2 pounds
2. Pounds of equivalent K_2O annually per 1,000 square feet on putting greens—
   - a. Sands and sandy loams .. 3 pounds
   - b. Putting green mixture* ... 3 pounds

For best results it appears that the annual amount should be split into fall and spring applications. The fall and spring applications should include all of the phosphorus and a part of the nitrogen in addition to the potassium. In other words, a fertilizer having a ratio 1-1-1, 2-1-1, or 3-1-2 is a good choice. Inasmuch as nitrogen fertilizer is usually applied regularly on the putting greens throughout the year, a high nitrogen to low potassium balance may develop resulting in greater heat damage to the turf. In this connection it is wise to consider reducing nitrogen slightly and increasing potassium a bit during the summer months. Applications of about

**According to specifications recommended by the USGA Green Section.*

½ pound of equivalent K_2O per 1,000 square feet should be ample unless the amount of nitrogen being used is exceptionally high.

Inasmuch as recommendations are nearly always given in pounds or equivalent K_2O, it is necessary to be able to calculate the amount of potassium fertilizer or mixed fertilizer needed to attain the recommendation. Suppose it is desired to apply one pound of equivalent K_2O per 1,000 square feet using a 12-4-8 fertilizer. The amount of the 12-4-8 fertilizer needed would be calculated as follows:

The equivalent percentage of K_2O in the mixed fertilizer is 8%, therefore each 100 pounds of the fertilizer contains 8 pounds of equivalent K_2O. Since one pound is 1/8 of 8 pounds, 1/8 of 100 pounds is 12.5 pounds, the amount of the 12-4-8 fertilizer which should be applied to 1,000 square feet. Such an amount of 12-4-8 would supply also 1½ pounds of equivalent N and ½ pound of equivalent P_2O_5.

Soluble salt crystals which cling to the foliage cause the injury called burning. Pelleted fertilizers are less likely to cause burning than crystalline or powdered materials. It is well to keep in mind that potassium fertilizer materials like nitrogen materials have a salt effect and will burn the turf if not applied properly. Potassium materials can be applied dry but to prevent burning the turf must be sprinkled immediately to wash the fertilizer off the tops. Muriate of potash can be dissolved in water and applied as a solution. It should be borne in mind also that uniform distribution of fertilizers is essential.

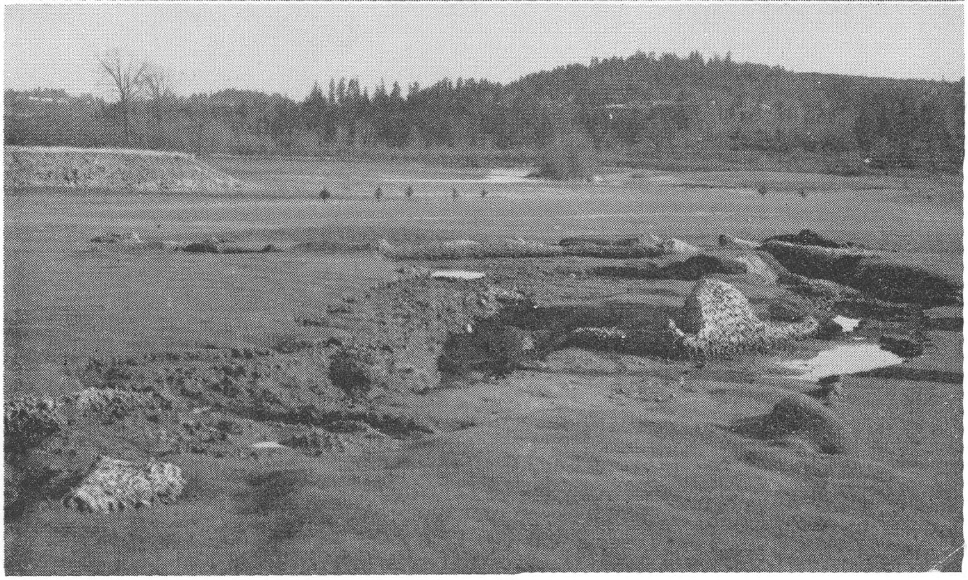
Potassium has been aptly called the neglected nutrient. Its effect on the growth and appearance of grass is not as pronounced as that of nitrogen, therefore a deficiency of potassium is not so evident and is often overlooked. From experimental evidence, we are certain that proper attention to potassium fertilization is essential for a healthy, vigorous turf.

Flood Damage in Oregon

The photographs on the next page and the front cover show some of the damage suffered by the Illahe Hills Country Club course in Salem, Oregon, from flooding of the Willamette River during Christmas week, 1964. Two greens were totally destroyed and although reconstruction is now underway at least seven months and a considerable expenditure will be needed before complete recovery is achieved.

The 11th green (see front cover) is situated in a bend of the river and was under 10 feet of moving water at the crest of the flood. It seems apparent that most of the damage to the green was caused by swift moving logs or trees as they floated down the stream and across the green. They tore through the sod, exposed the soil below and allowed the erosion process to begin.

To guard against future severe damage from flooding, the Club is considering elevating the green by several additional feet and having the elevation taper off to the upstream side. Also under consideration is the use of pilings on the upstream side to divert the flow around the green and to prevent debris from passing over it during flood stage.



USGA GREEN SECTION RECORD
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TURF TWISTERS

ACID SOILS

Question: In recent issues of a New Zealand turf publication, the virtues of acid soils have been described. What does the Green Section think about this? (MISSOURI)

Answer: There is not a simple answer to the question. Two fairly well established facts should be kept in mind. First, grasses will tolerate a rather wide range of conditions with respect to acidity and alkalinity, provided all of the necessary nutrients are supplied in adequate amounts. Secondly, a soil which is near neutral or just slightly acid in reaction will favor the availability of most plant nutrients. Therefore, we normally suggest that soils be maintained at somewhere near the neutral point.

The theory of acidifying soil has enjoyed some favor in the United States in past years. It is believed that clover and some other weeds are easier to control if soils are acid and that grasses will continue to thrive. While this is probably true, we have taken the position that it is preferable to control weeds by other methods and to maintain as good conditions for nutrient availability as is possible.

LEAD ARSENATE

Question: Is there any value in using arsenate of lead on putting greens? (CALIFORNIA)

Answer: It has been demonstrated many times that arsenate of lead is both a good insecticide for controlling soil inhabiting insects and an effective control of *Poa annua* and crabgrass. Its effectiveness as an herbicidal agent is modified however by the phosphorus content of the soil. Apparently high levels of phosphorus cause lead arsenate to be less effective and consequently much larger quantities must be used under such conditions.