Proceedings of Scotts Turfgrass Research Conference

Volume 5—Turfgrass Management

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PREFACE

These Proceedings consist of a series of papers presented at the Scotts Turfgrass Research Conference at Marysville, Ohio in the summer of 1974.

New approaches to turfgrass management which would reduce dependence on fossil fuel yet maintain a cleaner environment were underlying concerns of the symposium participants. It was appropriate, therefore, that Scotts invited speakers to discuss fertilization, pest control, and mowing of turfgrasses, three management practices highly related to energy use. The objective being to better learn to optimize the use of fertilizers and pesticides as fuel costs rise.

The Symposium also stressed the importance of *Extension Turf Specialists* in transferring research findings to the public. Innovative techniques in communicating new turfgrass management practices to the urban populace are outlined in the Proceedings by Robert O'Knefski. These techniques involving the use of radio, television, computers, and newspapers must become an integral part of all effective extension turfgrass programs.

The participants commend O. M. Scott & Sons for hosting this Symposium and publishing these Proceedings.

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THE EFFECTS OF MOWING ON TURFGRASSES

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Introduction

The effects of defoliating grasses were observed long before mechanical mowing existed. In Biblical times, domestic animals grazed near family dwellings to be safe from predators (Huffine and Grau, 1969). Repeated defoliation ultimately led to the decline of the grass stand and forced the animals to graze taller vegetation. When drought and heat occurred, closer grazed grasses were stressed more than those which were ungrazed. These adverse effects were observed, with little knowledge of the underlying reasons for them. Now, many centuries later, research has provided some understanding of the responses of grasses to defoliation. To fully understand these responses, continued research is necessary, because new cultivars with varied morphologies are continually being released. In early times, the aesthetic quality of grasses became appreciated and they were commonly used to accentuate ornamental plantings and formal gardens (Rhode, 1927). Recreation in these early times utilized clipped grasses for bowling greens which were the predecessors to present day golf greens. The game of golf brought a demand for more exacting playing conditions, but even in the early days of golf, sheep were used to "mow" the greens (Huffine and Grau, 1969). In general the effects of defoliation are the same regardless of the means by which it occurs (either animal or machine). This discussion will consider the effects of clipping height, frequency of mowing, and equipment adjustment on turfgrasses.

Clipping Height

Clipping height can be defined as the distance above the soil surface at which the turf is mowed (Beard, 1973). Turfgrasses vary in their inherent mowing tolerance. Utilization of the turf and its physiological condition are also important in determining the mowing height. As the cutting height is lowered within the tolerance range of any given turfgrass, the root system is adversely affected (Figure 1). This phenomenon has been well documented (Beard and Daniel, 1965; Biswell and Weaver, 1933; Creder, 1955; Davis, 1958; and Roberts and Bredakis, 1960). Depletion of carbohydrate reserves due to foliar priority for carbon sources is most often cited as the reason for decreased rooting at lower cutting heights (Beard, 1973) (Figure 1). It has also been postulated that clipping affects the concentration and translocation of root growth regulators synthesized in leaves.

Concurrent with depletion of carbohydrate reserves, and related to it, is a reduction in photosynthesis per unit area (Figure 1). After defoliation, a time lag exists in photosynthate production until regrowth of leaves has occurred. This regrowth is dependent on carbohydrate reserves. Once a sufficient light interceptive canopy is produced, carbohydrates can accumulate if environmental factors are favorable. Brougham (1956), has shown that higher clipping heights generally increase light interception and reduce regrowth time.

Turfgrasses vary in their tolerance to cutting height (Table 1). Growth habit and location of leaf primordia dictate tolerance to close mowing (Branson, 1953). Creeping bentgrass (Agrostis palustris, Huds.) has leaf primordia located near the soil surface, while primordia of tall fescue (Festuca arundinacea, Schrebs) are located approximately one inch above the soil. Within species, cultivars also exhibit different tolerances to height of mowing (Kuhn and Kemp, 1939). The improved cultivars of Kentucky bluegrass (Poa pratensis L.) ('Pennstar', 'Merion', 'Fylking', 'Baron', and 'Adelphi') tolerate closer mowing than the cultivars 'Delta', 'Park', and 'Newport'. Difference in growth habit (leaf angle and location of meristems) is the primary reason cited for these cultivar differences (Engel, 1966; and Wood and Burke, 1961).

Leaf angle differences are important in explaining the varied cultivar response to cutting height found among Kentucky bluegrasses. Leaf blades of improved cultivars orient more parallel to the soil surface than the upright common type. When defoliated, the lower leaves continue to provide the necessary canopy for light interception and continued production of photosynthate. This minimizes any time lag in photosynthetic efficiency, and reduces the depletion of reserve carbohydrates thereby allowing growth to continue. By contrast, when more upright cultivars are defoliated, much of the blade tissue is removed and regrowth of new leaves is necessary before photosynthesis per unit area returns to the predefoliation level. Resistance of bluegrasses to environmental stresses (drought and heat) is closely related to root production and carbohydrate reserves. The greater resistance that improved cultivars exhibit to these stresses is undoubtedly related to their morphology.

Rhizome and stolon growth do not follow as direct a correlation with defoliation as root growth has shown (Figure 2). Moderate defoliation actually enhances their production and is used to increase stolon growth during establishment of creeping bentgrass. However, frequent, close mowing can reduce rhizome and stolen growth. Since Kentucky bluegrasses are dependent on rhizome growth to provide recovery from injury, when closely mowed, their recovery is slowed. Sod strength is also reduced by close mowing which results in poorer footing on athletic fields.

Succulence of turfgrasses increases as cutting height is lowered (Madison, 1962). This succulent condition added to reduced rooting and a decline in overall vigor, place the plant in a physiologically weakened condition. Resistance to physiological stresses and disease attacks is reduced.

Increased succulence of tissue also increases the demand on the root system for moisture to maintain turgidity. Consequently, wilting occurs more readily on a given species when it is clipped closesly. Increased succulence and reduced rooting requires intensive irrigation management to maintain turfgrass quality.

Not all effects of mowing are deleterious. Closer clipping stimulates tillering, thus increasing shoot density (Madison, 1962; Schery, 1966) (Figure 2). Increased shoot density improves appearance and is a positive response to mowing as long as the height is within the tolerance range of the species. This increase in tillering occurs with the removal of stem species. This phenomenon becomes an important management tool in manipulating plant competition.

For example, mowing a mixed stand of Kentucky bluegrass and annual bluegrass (Poa annua L.) below the tolerance level of the Kentucky bluegrass favors the annual bluegrass (Davis, 1958). The mowing tolerance range of the annual bluegrass extends much lower than Kentucky bluegrass. When the clipping height is lowered below the tolerance of Kentucky bluegrass, the annual bleugrass is still increasing in shoot density. Consequently the Kentucky bluegrass is more competitive at high cutting heights.

Because shoot density increases when the cutting height is lowered, the number of leaves per unit area also increases. This increase in leaf number brings a concomitant increase in chlorophyll on a unit area basis (Figure 3). Actual color (darkness of green) may or may not follow this chlorophyll relationship. Cultivars within species differ in their color response to cutting height. Those with low leaf angles, which tolerate closer clipping tend to have darker green color when clipped closely. However, if the clipping is excessive, older, yellowing, senescening leaves are exposed plus new growth emerges which is lighter green. When this happens dark green color and overall appearance are reduced.

Leaf texture is also affected by mowing (Figure 1). Unclipped turf of any species has wider leaf blades than when the same species is mowed (Harrison, 1931). The closer the mowing height the finer the texture. Annual bluegrass leaves become quite fine textured when mowed at putting green height. Light interception is enhanced by wider leaves when turf is clipped higher. However, within the tolerance limit, closer mowing increases growth and number of shoots per unit area and tends to offset disadvantages related to reduced leaf width (Figure 1).

Some turfgrasses, particularly low growing types like creeping bentgrass and bermudagrass (cynondon dactylon (L) Pers.) can be adversely affected when clipping height is too high. Puffiness and thatch accumulation increases and return to proper clipping height must be a gradual process to avoid scalping.

Frequency

Frequency and height of clipping are interrelated and, as height is lowered, frequency must be increased to maintain quality. Madison (1960) determined that long intervals between mowings may improve quality and vigor. However, Crider (1955) concluded that no more than 40% of the existing leaf tissue should be removed with any one mowing.

Mowing frequency is primarily dictated by shoot growth rate. To avoid scalping, the frequency must increase when growth rate increases. When frequency does not change commensurate with an increased shoot growth rate, each mowing will remove an excessive amount of leaf tissue. This often causes the plant to undergo severe physiological shock. Clipping to remove 80% or more of the leaves resulted in complete root growth stoppage for 12 days (Crider, 1955). Root growth may not only cease, but ultimately there may be considerable root death (Beard, 1973).

Turfgrasses vary in their vertical shoot growth rate. Madison (1962) has shown tall fescue to have a rate nearly three times more rapid than bentgrass. Frequency of mowing, however, must be more rapid on the bentgrass because of closeness of cut, particularly on a golf green. Mowing frequency is determined by shoot growth rate, cutting height, use, and environmental conditions that affect the growth processes (Beard, 1973).

Generally, the effects of mowing frequency on turfgrasses are the same as for mowing height (Figs. 1, 2, and 3). The relationships shown on these graphs indicate that shoot growth increases as the mowing height is lowered. This is true as long as the height is tolerated by the species. However, as mowing frequency increases, the shoot growth rate will decrease. The advantage of reduced shoot growth rate with more frequent defoliation is that the amount of leaf removed is small and will readily fall down through the canopy of upright growing turf and negate the necessity of collecting clippings. Leaf tissue is composed of approximately 75-85% water and easily decomposed compounds and consequently contributes little to thatch. Clippings may contribute, however, if a thatch layer exists prior to mowing. Smaller leaf cuttings also fall deeper through the canopy which places them in a microclimate more conducive to decomposition (Beard, 1973).

Mower Adjustment

Adjustment, in this discussion, for rotary mowers refers to blade sharpness. Dull rotary mower blades shred rather than cut grass leaves. In some species, the fiber content of the vascular system (veins) is high and resists cutting, but shreds readily. Therefore, a severe reduction in aesthetic quality results, as exposed vascular tissue dehydrates and loses pigmentation. The bruised, shredded leaves are not only unattractive, but also provide points for entry for pathogens.

Reel mowers that are not sharp result in a "banding" of the leaf blades which detracts from the appearance. Reel mowers that are sharp, but out of adjustment, do not cut cleanly, leaving a ragged edge or a rippled effect.

Mutilated leaves of plants cut with either reel or rotary mowers lose water in excess of those cleanly cut. If turf is mowed when wet and the cut is not clean, the water film provides transportation for mycelium to invade the mutilated leaf.

Turf managers who do a precise and conscientious job of growing turfgrasses can have their efforts completely negated by improper adjustment of mowing equipment.

Summary

The effects of mowing (height, frequency, and equipment adjustment) on turfgrasses are generally detrimental from a physiological point of view (reduced roots, rhizomes, carbohydrate storage and increased succulence). Aesthetic quality, however, improves because of increased shoot density. Mowing is necessary to maintain a groomed appearance. Use of the turf dictates mowing management. Successful turfgrass managers adequately compromise the physiological status of the plant with the demands of the clientele utilizing the turf.

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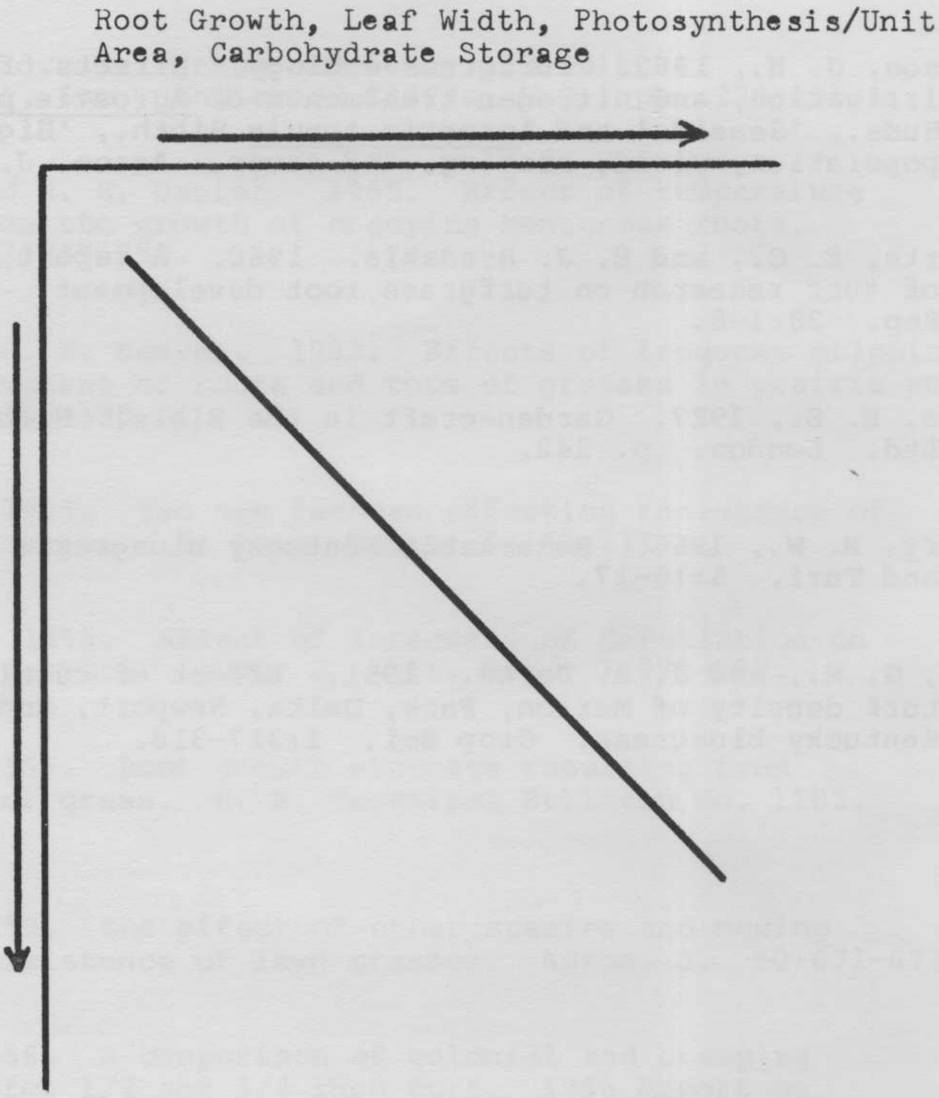

Figure 1. Response of four growth factors to cutting height.

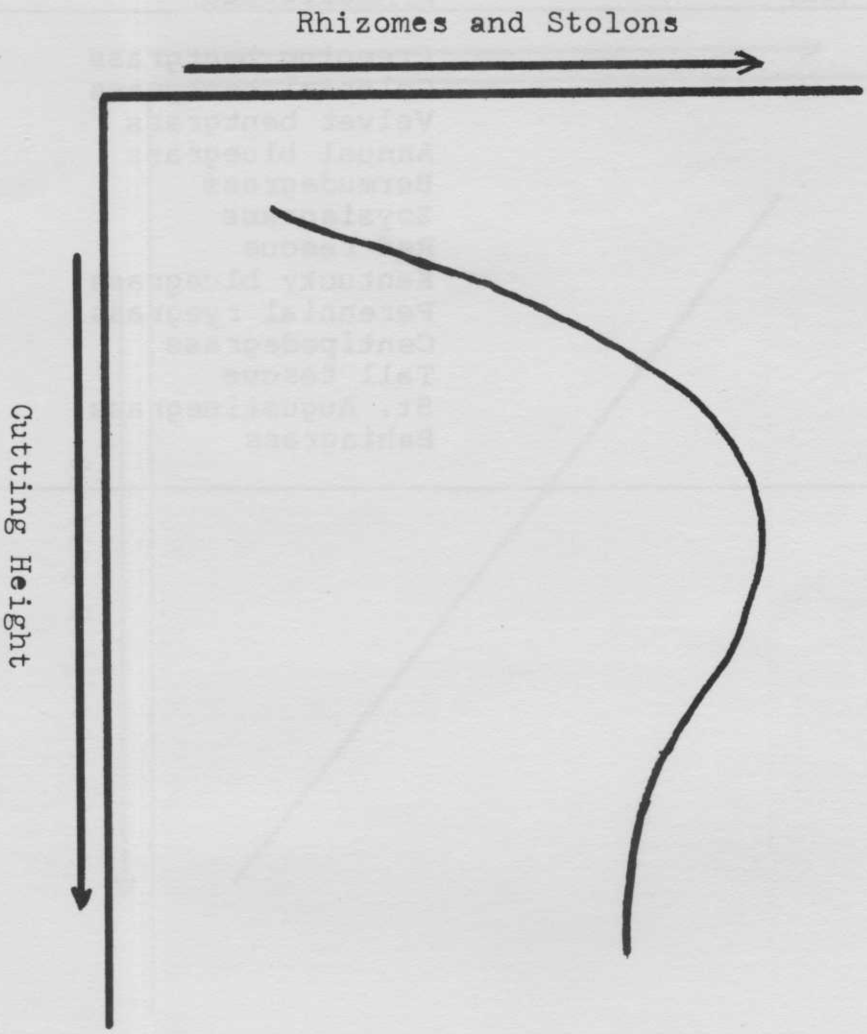

Figure 2. Response of lateral shoots to cutting height.

Table 1. Cutting height ranges tolerated by several turfgrasses.

Cutting Ht. (cm)	Turfgrass
0.5-2.5	Creeping bentgrass
	Colonial bentgrass
	Velvet bentgrass
	Annual bluegrass
	Bermudagrass
	Zoysiagrass
2.5-5.0	Red fescue
	Kentucky bluegrass
	Perennial ryegrass
	Centipedegrass
2.0-7.5	Tall fescue
	St. Augustinegrass
	Bahiagrass

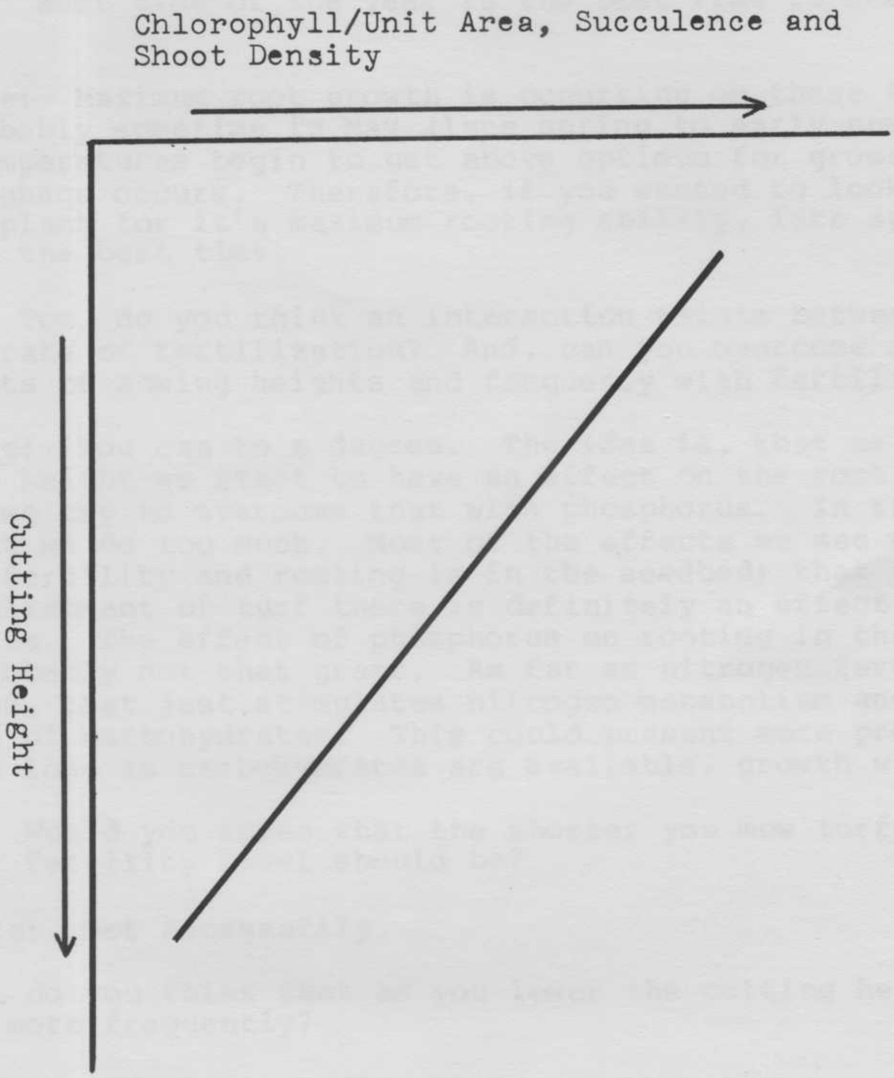

Figure 3. Response of three growth factors to cutting height.

Discussion Period

Dr. Ensign: What time of the year is the best time to measure root growth?

Dr. Watschke: Maximum root growth is occurring on these temperate species probably sometime in May (late spring to early summer). As the soil temperatures begin to get above optimum for growth of roots, sloughage occurs. Therefore, if you wanted to look at an individual plant for it's maximum rooting ability, late spring would probably be the best time.

Dr. Duble: Tom, do you think an interaction exists between mowing height and rate of fertilization? And, can you overcome some of these effects of mowing heights and frequency with fertilizer?

Dr. Watschke: You can to a degree. The idea is, that as we lower the cutting height we start to have an effect on the root system; therefore, we try to overcome that with phosphorus. In that regard, I doubt that we do too much. Most of the effects we see with phosphorus fertility and rooting is in the seedbed; that is, in the early establishment of turf there is definitely an effect on rooting by phosphorus. The effect of phosphorus on rooting in the mature stand is probably not that great. As far as nitrogen fertilization is concerned, that just stimulates nitrogen metabolism and increases utilization of carbohydrates. This could present more problems. However, as long as carbohydrates are available, growth will occur.

Dr. Duble: Would you agree that the shorter you mow turfgrasses the higher your fertility level should be?

Dr. Watschke: Not necessarily.

Dr. Duble: do you think that as you lower the cutting height you should mow more frequently?

Dr. Watschke: Definitely. The closer you mow, the more often it is necessary to mow. This also goes back to the question of how much do the clippings that fall back on turf contribute to thatch problems. If you are mowing close, let's say you are mowing bluegrass at an inch and a quarter, and if you frequently mow, the amount of debris that is removed each mowing is reduced. Therefore, the clippings will pass through the canopy and can be decomposed easily and you won't have a problem of clipping removal or suffocation.

Dr. Daniel: Do you think that the length of the clippings should about equal the height of the cut?

Dr. Watschke: In terms of how much should be removed to maintain the best physiological condition of that plant, I think that you can safely go back to the "1/3 rule". For example, if the turf is an inch and a half you can clip it to an inch. However, if it's two inches and you want it to be one inch, and you take it down to one inch all in one operation, that's too severe. You'll end up with a scalped condition and encourage weed invasion.

Dr. Newman: Is there an ideal leaf area index for turf after mowing? It would appear that leaf area index would be more directly correlated to mowing rather than the height of cut when you are dealing with different morphological types of bluegrass.

Dr. Watschke: I haven't tried to calculate the leaf area index of any turf. If you have something like a corn plant when it has wide leaves where you can use the techniques commonly used to measure leaf area index it's not too difficult, but if you're going into a turf and trying to calculate what the leaf area is above a given area of ground it gets to be more difficult. What we really need to be concerned about is that after it's defoliated the amount of light interception has not been reduced drastically. This is where these different morphologies come into importance. I don't think I could tell you exactly what leaf area index would be precise for bluegrass. Someone should find out. It would be difficult, though.

Dr. Schmidt: Tom, I was wondering if in your opinion, is there any advantage to lowering the mower in the fall and spring and raising it in the summer? I'm speaking of temperate species, now.

Dr. Watschke: I think this is a positive management approach. In altering the height of cut we put that plant in it's best physiological condition. If you raise the cutting height during the summer, obviously you're going to have more leaf area for photosynthesis. Also, by raising the cutting height you're going to have some increase in insulation at the soil surface in that micro-climate at the crown area. As far as lowering it in the fall, generally I don't think that's such a bad idea because most of the processes going on in the fall are not foliar. Even if you fertilize heavily in the fall you will not necessarily reduce the carbohydrate supply because, the foliage, due to photoperiodism and temperature, is not being produced at a rapid rate; also light intensity is decreasing. I think this is a good point to discuss and it is a valuable technique too, i.e. if you can raise the cutting height in the summer and provide more leaf area.

Dr. Hall: Tom, John Madison's work with bentgrass indicated no effect on chlorophyll per unit area, as affected by mowing height. In fact, he was showing increased density with lower mowing heights and less chlorophyll per plant. Do you think this difference is simply a general difference or are there other factors involved? And secondly, have you seen lower chlorophyll per plant in your work with bluegrass?

Dr. Watschke: We haven't analyzed chlorophyll at all. The point I was making was that as the amount of shoots increase with lower cutting height, the amount of chlorophyll that you can take off a given area would be greater, just from the fact there are more leaves present. I think if you look at Madison's work you'll find that was the only time he showed an increase in chlorophyll. However, on a per plant basis, chlorophyll didn't increase, it decreased.

Dr. O'Knefski: Tom, would you like to comment on leaving clippings versus taking clippings off, especially on bluegrasses?

Dr. Watschke: Well, if the frequency is right, I don't think there is any problem with clippings falling back on the turf. I don't think a person can buy a mower without somebody impressing upon him the necessity to buy the catcher. Most homeowners you see dumping their clippings in a garbage bag or some type of receptacle because it's been impressed in their mind that it is undesirable to leave any clippings behind. Of course, it is important to remove them if they're on the lawn because you can get involved in suffocation and/or a shabby appearance if they are in excess. But, if the leaves fall through the canopy, and this is what will happen if the frequency of mowing is right and a reel type mower is used, then there is not a major problem. With rotary mowers, on the other hand, the clippings tend to accumulate in the housing and you end up with mounds of shredded debris scattered on the turf and those have to be removed.

Mr. Papanos: Tom, comment on your verti-cutting weekly intervals on Penncross. Would you comment on the depth and does this pick up any thatch?

Dr. Watschke: This verti-cutting on a weekly basis is something we are starting to do at the turf plots at Penn State because we don't receive typical golf course traffic. Our fertility level is moderate but it's adequate to keep the bentgrass from becoming too stemmy. We do get into a puffy condition and we have a problem with scalping because of this puffiness. Therefore, we use a verticut unit on this particular area, but very lightly. We're not going to the soil, but going down into the thatch where the stolons are. Our maximum accumulation of litter in the baskets occurs when annual bluegrass is flowering.

Dr. White: Not a question, a statement on the collecting of the clippings. A long time ago, after running into a few accidents with rotary mowers, I came to the point where I recommend collecting clippings anytime anybody uses a rotary mower, just as a safety factor. I think this might be something you want to consider.

Dr. McVey: Tom, I wondered if you had looked at the use of growth regulators not from the standpoint of reducing mowing frequency but from the standpoint of reducing some of the mowing side effects, the shock effect, etc. In other words, you might use the same mowing frequency but you might avoid some of these side effects by using growth regulators.

Dr. Watschke: I've looked at growth regulators, but for the most part just from the point of growth reduction, decrease in mowing, the effect on carbohydrates, and attempting to reduce the flush of growth in spring for possible accumulation of carbon materials for use by the plant later in the year. I haven't looked at growth regulators from the point of view of how you might get away from some of the mowing effects, like scalping or shock mowing. Because of the side effects from growth regulators I think at this time we can only hypothesize how they might become involved in a management program if in fact the time comes when they do produce what I would call specific-organ retardation. By that I mean, affecting just the leaves, and not the rhizomes, the solons or the roots. Most of the growth regulators we have today inhibit growth of all of these plant organs. Furthermore, in sports turf, we're involved in recovery from divots, kicked out sod plugs by football players and what have you, as well as regrowth from leaves. So, if we can't recover from injury, insect disease attack or whatever, we're not in the ballgame.

TURF FERTILIZATION

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Today I would like to review some of our research findings related to the nitrogen, phosphorus, and potassium sources, rates, and programming for seedling and established turf areas.

Nitrogen Needs of Established Turf

Turfgrass is extremely efficient at utilizing nitrogen as compared to other crops. The massive root system essentially assures very little nitrogen will be leached from the growing zone when applied at normal rates of application (1 - 2# N/M). If a completely soluble source of nitrogen is used, it is taken up very efficiently but over a short period of time resulting in excess turf growth which may lead to scalping by mowers and increased susceptibility to certain disease. By utilizing a slowly soluble source of nitrogen such as the synthetic or natural organics, the nitrogen is not absorbed all at once but over a sustained period of time thus avoiding luxury consumption and excessive vegetative growth. Turf quality and density is generally enhanced since the sustained release period of nitrogen provides nutrients as needed by the turf.

The nitrogen requirement for quality turf is quite high, ranging from 3 - 5# N/M/year for bluegrass to 1 - 3# N/M/year for the fescues. If the turf is watered during dry periods there is essentially a continuous requirement for nitrogen from the soil media. If these demands are not met, turf quality and density will be reduced, thus opening up the turf to weed invasion.

Nitrogen Needs of Seedling Turf

A new seeding has a relatively low biological need for nitrogen until the second to third week after germination. At that time the relative demand is still very low as compared to phosphorus. The presence of nitrogen in combination with phosphorus aids in the uptake of phosphorus which is a key element in early seedling development. The nitrogen demands during the first 6 - 8 weeks can be satisfied with as little as 0.75 to 1.25 lbs. N/M.

The nitrogen should be applied at seeding time since it is very difficult to get onto the newly seeded area once you start your watering program. In addition, no real advantage is gained by delaying the application particularly if slowly soluble sources of nitrogen are applied at seeding time.

Phosphorus Needs of Established Turf

Established turf is very efficient at extracting phosphorus from the growing media to meet biological demands. There are, however, periods during the season when phosphorus availability in the soil is reduced because of cool soil temperatures (50° F). If the soil is low in phosphorus (30# P/A) and the soils are cool, a phosphorus deficiency may be expressed by a very slow growth rate, (poor green-up in the early spring and early fall discoloration) thinning of the turf, and purple discoloration of the older leaf tissue. If the soils have greater than 30# available phosphorus per acre, response to phosphorus is seldom seen. If excessive rates of phosphorus are applied, iron deficiency can be induced because of a phosphorus-iron complex which is formed in the soil. As the soil phosphorus levels exceed 200 lbs. available/acre, iron deficiencies become evident in such grasses as zoysiagrass and St. Augustinegrass. For cool season grass (e.g. bluegrass), a level of 600 - 1000 lbs. available P/acre will cause an iron deficiency. These deficiencies can be corrected by applying an iron source using 1 - 4 # Fe/acre applied to moist foliage in the spring and fall when expression is more prevalent.

High phosphorus levels can also inactivate other minor elements such as manganese, zinc, and copper with nutrient deficiency symptoms expressed in that order.

Since established turfgrasses are very efficient at extracting phosphorus from the soil media, only limited benefit is gained in building the soil phosphorus level above 60 lbs. available P/acre. In addition, phosphorus mobility is very limited in the soil; consequently, fixation of phosphorus on the soil mass is very high. Thus leaching of phosphorus is not a limiting factor.

Phosphorus Needs of Seedling Turf

Phosphorus availability to the developing seedling is essential if one expects to achieve success with a new seeding. The phosphorus must be in immediate contact with the emerging seedling radicle. Consequently phosphorus placement for developing seedling turfgrasses is very critical. Phosphorus placed at a 6" depth is of little value when the roots have penetrated only 2" into the rooting media. For maximum phosphorus uptake by seedlings, phosphorus should be placed in the upper 1/4 to 1/2 inch of the seedbed at the same time the seed is incorporated. Using this technique reduces the total phosphorus required for optimum seedling development. On soils extremely deficient in phosphorus (5# available P/acre), rates of approximately one lb. of P_2O_5/M have assured excellent seedling development. The phosphorus is taken up by the emerging roots and mobilized to the growing root tip thus assuring excellent root penetration into soils that are highly deficient in phosphorus. Soil phosphorus levels are not increased by these low rates of phosphorus; however, turf development has been shown to be very satisfactory.

Phosphorus levels in subsoils is often in a very deficient range (e.g., 20# available P/acre). Consequently in areas where subsoil may have been used in the preparation of a seedbed the addition of phosphorus at seeding time is essential. In the absence of phosphorus germination will not be suppressed but development is delayed so dramatically that other stress factors, (drought, heat, freezing, and thawing) essentially assure a seeding failure. All too often a seeding failure is blamed on bad seed and/or poor watering practices when in reality it was a phosphorus deficiency.

On soils with adequate native levels of phosphorus (greater than 30# available P/acre), the addition of phosphorus assures a more rapid seedling development but is not essential for seedling survival.

In the case of sprigs or sod used for establishing a new stand of turf, phosphorus availability is not as critical since phosphorus is carried over in the vegetative parts. However, more rapid establishment is assured by applying approximately one pound of phosphorus (P_2O_5) per 1,000 sq. ft. As stated earlier the phosphorus should be placed in the root zone (the upper one inch of the soil profile).

It should be stressed again at this point that phosphorus alone will not assure rapid seedling development. Nitrogen also plays a role in improving phosphorus uptake and as a nutrient source in its own right.

If phosphorus was inadvertently omitted at seeding time, success can still be achieved by applying a phosphorus source anytime within 4 - 7 weeks after seeding or before any excessive stress is placed on the seedling (drought, heat, freezing, and thawing). An acceptable turf quality is significantly delayed under these conditions, however. On newly constructed greens which are low in native phosphorus (5# available P/acre) it is important to incorporate phosphorus into the upper 6" of the soil prior to seeding. Five to seven pounds of P_2O_5/M is recommended.

Potassium needs of Established Turf

Turfgrasses in general are very efficient at utilizing potassium. Under low to moderate maintenance programs (e.g. when the nitrogem level does not exceed 3 lbs. N/M/year) potassium needs of turf are very low. As little as 0.5 lbs. N/M/year is adequate. As the maintenance program increases, higher levels of potassium are needed since growth and turf density is greatly increased.

Potassium deficiencies are expressed by a thinning of the turf, browning of the older blades, and a droughty appearance. These symptoms can also be mistaken for leafspot (Helminthosporium) if one does not examine the leaves closely for necrotic lesions. Under field conditions one rarely sees turf which exhibits these symptoms; however, incipient deficiency symptoms may occur causing a reduction in general turf vigor but not advancing to an acute level of deficiency symptoms.

Because of the possibility of incipient deficiency symptoms most fertilizers contain some potassium to assure that this element does not become limiting.

Potassium has an important role in the recovery of turf grass from certain disease infestations. The severity of the disease is not reduced but the recovery rate after the disease has been checked by chemicals or climatic changes is very dramatic.

Turf wearability (ability to withstand foot traffic) can be improved by following a good potassium program. This, however, appears to be associated with the direct effect of potassium on reducing calcium uptake. As the calcium level in the tissue decreases, the leaf becomes more rigid and thus appears to withstand a greater traffic stress.

Potassium levels in the soil should range from 100 - 300 lbs./acre. As the level varies on either side of this range, deficiencies or toxicity may occur. In general the deficiency can be corrected by as little as 0.1 - 0.5 lbs. N/M. In the case of the toxicity it is generally expressed as a calcium or magnesium deficiency since potassium has a marked effect upon the uptake of these two elements. The addition of dolomite will correct this situation.

Potassium Needs of Seedling Turf

One can demonstrate a response of turf seedlings to potassium within 3 weeks after seeding on a pure silica sand devoid of a potassium source. However, under field conditions, response of turf in the seedling stage to potassium is very difficult to demonstrate even on extremely deficient soils. In most cases the lawn installer does not know the level of potassium in the soil so a fertilizer containing a minimum of 0.25 lbs. N/M is suggested for insurance.

Nutrient/Turf Genotype Interaction in a Shady Environment

The turfgrass complex can be altered by modifying the phosphorus program followed in a shady turf environment. In wooded lawn areas it is desirable to maintain a mixture of cultivars containing bluegrasses and fescues in the northern USA. If any one of these components is discouraged, the turf stand may be more susceptible to disease damage. Unless one is using an improved bluegrass selection, bluegrass in general can be susceptible to mildew and leafspot under these conditions. Fescues will be more prone to thinning out in the summer from leafspot if non-improved varieties are used. By maintaining a good nitrogen and phosphorus balance in the root environment a good balance of bluegrass/fescue may be maintained. If the phosphorus application exceeds 1.8# P_2O_5/M/year, the bluegrass growth is accelerated while the fescue growth is suppressed resulting in essentially a 100% bluegrass stand. Bluegrass (common type) is inherently less tolerant to shade stress than fescue; consequently, the bluegrass population decreases and eventually a very thin stand results.

If the phosphorus level is maintained at 0.6 lbs. P_2O_5/M/year, an optimum balance of fescue to bluegrass can be maintained. By reducing the phosphorus level down to zero lbs./year, the fescue becomes the dominant grass species thus reducing the chances of survival as compared to a blend of bluegrass and fescue.

For the optimum seed blend and fertility program for a shady area one should select improved varieties of bluegrass and fescue in a 50/50 - 75/25 blend (percent by weight) and fertilize with 4.0 lbs. N/M/year, using a fertilizer which will provide 0.4 to 0.60 lbs. P_2O_5/M/year. This can be accomplished by using a 5/1 to a 10/1 N/P_2O_5 ratio.

If a high phosphorus program is used in the shade, the addition of fungicide is essential to lessen damage to the bluegrass.

Nutrient/Turf/Weed Interaction

Grasses are very competitive with undesirable plant species such as dandelion, clover, and crabgrass if the turf is maintained on an adequate nutrient program. In order to assure limited weed invasion a minimum of approximately 4.0 lbs. N/M/year should be applied in 4 equally spaced applications during the growing season. Higher rates are of little additional value in suppressing weed invasion; however, lower rates reduce the competitive nature of bluegrass dramatically. For maximum speed of weed removal a herbicide is recommended followed by a good fertility program as stated above. If one continues to follow this fertility program, only occasional spot treatments would be needed to prevent unsightly weeds. However, if the turf is thinned as a result of disease invasion, traffic stress, drought, insects, etc., then weed invasion can be expected. This would call for both pre and post emergence herbicide treatments. After the turf density is brought back to an adequate level, additional herbicides should not be needed except for occasional spot treatment.

Programming (See Table 1)

Looking at the function of each major element in seedling and established turf development provides insight into the selection of the proper fertilizer ratio, rate, and frequency of application to maintain quality turfgrasses. Studying the turf requirements for each individual element can be quite confusing; however, once the basic ratio for seedling and established turf is determined then it becomes a matter of selecting the proper time to apply the fertilizer to realize maximum efficiencies of utilization by the turfgrass plant.

A. New Seedings

A complete fertilizer containing a high phosphorus content will assure maximum turf performance even on soils extremely deficient in phosphorus. Work the phosphorus and the seed into the upper 1/4 - 1/2 inch of the seed bed.

A fall seeding is highly recommended. If a spring seeding is essential, weeds may become more of a problem as compared to a fall seeding. In this case, there are combination products containing fertilizer and herbicides for new seedings that will prevent or suppress weed development thus allowing the grass seed to develop free of competition. (3-4-1 ratio plus siduron).

Starting 6 - 8 weeks after seeding apply 0.9 - 1.25 lbs. of N/M using a fertiizer analysis such as a 30-3-10 or a 34-5-5. Repeat this application every 6 weeks until 100% turf density is realized.

B. Established Turf

As reviewed earlier, established turf has a very low phosphorus requirement, consequently a N/P_2O_5 fertilizer ratio such as a 10/1 to a 6/1 is preferred.

For optimum bluegrass turf development apply 3.5 - 5.0 lbs. nitrogen per 1,000 square feet/year. Fine fescue has a lower nutrient requirement than bluegrass and responds very well to 1.8 - 2.6 lbs. nitrogen per 1,000 square feet/year.

The minumum program suggested will maintain fairly good turf density and quality; however, one can expect more weed invasion and marginal turf performance during stress periods (traffic, disease, insect, moisture, light stress).

By following some of these simple fertilization principles one can expect excellent turf quality which will withstand a wide range of environmental stresses.

Discussion Period

Dr. Keen: I wondered about the form of the iron that you are using as an antagonist for zinc and copper toxicity.

Dr. McVey: That was ferrous ammonium sulfate formulated on vermiculite and Iron S is the product name.

Dr. Keen: It is not a chelate, but ferrous ammonium sulfate?

Dr. McVey: Yes, ferrous ammonium sulfate.

Dr. Keen: Okay, that is what I was concerned about, I thought possibly you were chelating the zinc and copper.

Dr. Daniel: On some calcarious sand at a pH of 5, which we have not fertilized, we maintained a phosphorus deficiency for 2 years and it was visable as a purpling. It had 6 pounds available P per acre. Adjacent areas with just 19 pounds did not show a deficiency. When we added phosphorus, we could correct it.

Dr. McVey: The green on which work was done here was running around 10 pounds of P per acre. It was a new golf course with modified greens. I do not believe the green was a USGA type, however.

Dr. Ward: A lot of times when urea type nitrogens are applied after an application of lime or basic slag, a release of ammonia results in a severe burning of the grass. Do you have any problems with your UF nitrogen sources releasing ammonia in a toxic amount when applied immediately after liming or the application of basic slag?

Dr. McVey: We have done work on that under greenhouse conditions. We brought in soils that were very acid and applied lime at very high levels followed with applications of methylene urea type products. Under those conditions we did not observe a problem, however we believe it is a good rule of thumb to avoid applying nitrogen fertilizer and lime at the same time.

Dr. Kaufmann: I noticed with interest your reference to the soils in Florida, and how with an application of fertilizer you improved the environment. Ironically, we have a situation on Long Island where the nitrates in the ground water are now above 10 parts per million. It was suggested that we cease all turfgrass fertilization so that we do not have problems like this again. How can we compromise on a point like that?

Dr. McVey: I think one thing is to make the authorities aware that all nitrogen sources are not alike. We have substantial differences between nitrogen sources and it is quite easy to demonstrate this by using two beakers of water and putting soluble nitrogen in one and some of the new improved formulations which utilize microbial action for N release in the other. I just don't think the authorities are aware of the way we can control the release of nitrogen. I think one or two good demonstrations might open their eyes.

Dr. Cott: What has been your experience with high accumulations of phosphorus as it relates to interaction with any of the other nutrients? I am talking of levels that might run as high as 250 to 500 pounds of phosphorus per acre.

Dr. McVey: We have not observed problems to date. We had a test in the greenhouse where we used tenfold increments starting with 0.2 pounds of P_2O_5 per thousand square feet and went up to 200 pounds per thousand square feet. The 200 pounds per thousand caused the soil to foam and we had a nice reaction in which nothing grew. The 20 pounds per thousand square feet appears to be the breaking point if you incorporate it in the upper soil layers, and it is applied in one applcation. Another situation arises if you keep applying phosphorus repeatedly. There are reports that you can induce zinc and/or iron deficiencies. In Juska's work, he used very high levels of P before he had a problem. The thing we have to watch is that phosphorus is a natural resource and too many times we use more than needed. I have not seen a problem with excess phosphorus in our work other than this seedling test which I just mentioned.

Dr. Duble: Dr. Ward, I would like to make a comment regarding your question. I recently saw overseeded greens fertilized on Monday with urea formaldehyde and lime was applied on Tuesday and Thursday all the winter grass was burned. There was some indication that a herbicide was present in the lime, but it is also possible that ammonia was released and did burn the winter grass. It did not affect the bermudagrass. I would also like to ask Dr. McVey to repeat what he said earlier regarding pH and nitrogen release from IBDU.

Dr. McVey: In both field and greenhouse tests, once the pH approaches 6.5 or above we found essentially no release of the nitrogen from IBDU even at rates as high as 10 to 12 pounds of nitrogen per thousand square feet. In fact, we questioned the technicians to find out if they had applied the material. We are not getting the release of nitrogen at high pH levels. This is documented in the literature. The work cited in the Japanese literature shows a dramatic effect of pH on nitrogen release from IBDU.

Dr. Kinbacher: When you are speaking about rates of P you are talking about P_2O_5 but some of us researchers say P and mean actual P. then when we deal with the homeowner and try to explain to him what P_2O_5 is we really have problems. Is there any trend in the industry to go to actual P and actual K instead of the system we have now?

Dr. McVey: There is a trend, in fact, that trend started about ten years ago, but I don't think they made much progress. On our fertilizer bags it's still P_2O_5. I am so used to that, I would really hate to change.

Dr. Kinbacher: The label will indicate a lower amount if you express phosphorus as P. So it looks like some of the resistance is in industry. It would be a lot easier to deal with the homeowner if we use P.

Dr. McVey: I think ecologically, instead of putting on 0.3 pounds of P_2O_5 you would be putting on 0.13 pounds of P, you might make the ecologists feel a little better.

Dr. Hall: Dr. McVey, I am often confronted with very practical homeowner questions. One of these that I am asked most frequently is, how can you continue to recommend nitrogen fertilization on home lawns when the farmers cannot get enough nitrogen fertilizer for food? I am interested in how Scotts is facing this question.

Dr. McVey: Mr. Simmons is probably closer to that than I. I am in the research phase, and prefer that he answer that question.

Mr. Simmons: John, this is a very important subject. I am sure there will be a great amount of discussion concerning this question. If it ever comes to the point where fertilizer supplies are not adequate to meet food production requirements, then the latter need would have to have preference.

Mr. Cantu: We checked the percentage of fertilizer used in the turf industry versus the agricultural industry and we found that somewhere around 3% or so goes on turf and the balance is agriculturally used. I think when you put it in perspective like that it is much easier to handle. It really does not have much of an impact and I found that is a really good way to handle it. A local superintendent sometimes gets questioned from his members and so we were looking for a way to help him with an answer. We found that the percentage is so small that the impact on the food crop need is relatively unimportant.

Dr. Schmidt: Dr. McVey, from your discussion, I got the idea that the more vigorous you push the grass plant, the better it is. Do you feel that continuous nitrogen feeding of turfgrass is really for turfgrass vigor?

Dr. McVey: The more we push with nitrogen the greater the need for all essential elements. For a period of time we might have more vigor, but once the potassium and phosphorus drop, then calcium and magnesium cause problems. We do not want the most vigorous plant. If we were producing corn, we would want a very vigorous plant for the highest yield, but we do not want that on turfgrass. We can even use nutrients to our advantage to reduce the mowing fequency. We want something that is between these two extremes. Again, when I say the most vigorous, I mean those that are giving balanced growth.

GUIDES FOR DEVELOPING AN IRRIGATION PROGRAM FOR TURFGRASSES

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The time has arrived in turfgrass irrigation procedures when one can no longer solely rely on his artistic judgement in the design, installation, or use of sophisticated irrigation equipment. Instead, decisions must be based on knowledge of the grass being grown, the characteristics of on-site soil, the water use rate, and, ultimately, the resupply of water by irrigation to insure an adequate soil-water reservoir.

If one observes turfgrass "in profile" it then becomes more obvious that the infiltration of water into the profile, the percolation of water through the profile, the depth of roots in the profile, and the water holding capacity of the soil are important in determining the design and use of an irrigation system.

Infiltration and Percolation

Water must first enter the soil through the process of infiltration. Variation in infiltration rates are dependent on soil texture, topography, thatch accumulation, degree of soil wetness, and level of compaction. As an example, a relatively level, sand-based putting green with limited thatch can have infiltration rates ranging from 1 to 20 inches per hour. In contrast a clay loam soil on a rolling, moderately compact fairway can have an infiltration rate of 0.10 inches per hour or less. Irrigation equipment <u>must be designed and used</u> with knowledge of this ultimate infiltration rate. Water applied at rates in excess of the infiltration rate results in pounding and/or runoff.

If a soil is of uniform texture and acceptable depth, percolation rates are seldom a limiting factor in irrigation practices. Variables such as shallow soils or layered soils of different texture, however, must be considered if they are a component in the water reservoir profile.

Water Availability

All soils contain two water fractions when viewed in terms of plant absorption. The first, unavailable water, is tightly held by mineral and organic particles and is unavailable for plant use. The second, available water, is that amount the plant can absorb for transpiration and metabolism. The amount of available and unavailable water differs with different soil textures. Table I gives a general relationship between soil moisture characteristics and soil texture.

Table 1. Available and unavailable water per foot of soil.

	Inches per foot	
Soil Texture	Available	Unavailable
Sand	0.4 - 1.0	0.2 - 0.8
Sand and Loam	0.9 - 1.3	0.9 - 1.4
Loam	1.3 - 2.0	1.4 - 2.0
Silt Loam	2.0 - 2.1	2.0 - 2.4
Clay Loam	1.8 - 2.1	2.4 - 2.7
Clay	1.8 - 1.9	2.7 - 2.9

After Buckman and Brady.

These data are approximate but nevertheless give an insight into the amount of water that is available per unit depth for plant use. This information, in conjunction with a knowledge of root depth, gives an indication of the amount of water that should be supplied by irrigation if plants reach water stress.

Turfgrass Species

When considering turfgrass in profile, it must be emphasized that turf species naturally differ in their rooting ability. In addition to species differences, root depths are also influenced by seasonal fluctuations (greatest root growth occurs in fall, winter and spring), management practices such as mowing and fertilization, and on-site soil compaction. The best method to determine rooting depth in a particular location is through physical inspection, however, a general guide to rooting depths is illustrated in Table 2.

Table 2. Relative root depths of cool and warm season turfgrasses under normal use conditions.

Cool Season Grasses	Root Depth
Kentucky bluegrass	Shallow
Creeping bentgrass	Shallow
Colonial bentgrass	Shallow
Red fescue	Shallow
Tall fescue	Intermediate
Annual bluegrass	Shallow

Warm Season Grasses

Bermudagrass	Deep
Zoysiagrass	Deep
St. Augustinegrass	Intermediate

As can be seen, rooting depths vary considerably. Since it should be the objective of irrigation to supply water throughout the root system, rooting depths and soil texture play an important role in both the amount of water to apply per irrigation time and the irrigation frequency.

Water Use

Water is used or lost from a turfgrass area in four ways: percolation below the root system, runoff because of a differential between application and infiltration rates, evaporation from the soil surface and plant leaves, and transpiration/metabolism through the plant. Evaporation and transpiration generally describe water use and, together, they are referred to as evapotranspiration. Water use by evapotranspiration is influenced by the following factors:

1. Radiation - As the total radiant energy that reaches the turf increases, there will be an increase in water use (more water use during the long, clear days than short, overcast days),
2. Temperature - Water use increases as temperature increases,
3. Wind - As wind velocity increases, water use increases,
4. Humidity - Water use decreases as humidity increases.

Other factors such as rainfall, soil fertility, and growing season, may also influence water use. The question then arises, "how do we calculate the amount of water that can be expected to be used from a turfgrass sward?" The answer is important both for the designer, who needs peak monthly water use data for design purposes, and for the user, who should have an idea of water use under given environmental conditions.

Calculating Water Use

To obtain a method that could be used to calculate anticipated water use in a given area of low humidity, the Blaney-Criddle formula (1) was tested. The Blaney-Criddle formula relies heavily on total radiant energy, expressed as daytime hours, and temperature, expressed as mean monthly temperature in F.

It has been a very successful tool for predicting water use of agricultural crops in areas with low humidity. The seasonal formula is expressed as

U = KF where:

U = Water use in inches (consumptive use)
K = A calculated seasonal coefficient
F = Sum of monthly factors (f) where

f = t x p

t is the mean monthly temperature in F
p is the monthly percentage of daytime hours which is based on latitude.

The monthly consumptive use can be calculated as follows:

u = k f
u = monthly water use in inches
k = a calculated monthly coefficient given in Bulletin #1275 (1)
f = t x p

where t = mean monthly temperature in F
and p = mean percentage of daytime hours.

By using U. S. Weather Bureau information for the Santa Ana, California, area, the Blaney-Criddle formula was calculated to estimate water use at the Santa Ana location. The results are presented in Table 3.

Table 3. Blaney-Criddle formula applied to turfgrass water use in Santa Ana, California.

Month	Mean Temp. (T)	Day* Hours (P)	Use Factor (F) T x P	Use* Coefficient (K)	Use Inches F x K	Avg. Rain	Effect. Rain	Use Minus Rain	Irrigation Requirement
Jan	53.0	7.09	3.76	.24	.90	2.90	2.61	-1.71	
Feb	54.5	6.90	3.76	.38	1.43	3.14	2.57	-1.14	
Mar	57.1	8.35	4.77	.55	2.62	2.16	1.94	0.68	
Apr	60.6	8.79	5.33	.70	3.73	1.33	1.26	2.47	
May	63.8	9.71	6.19	.88	5.45	0.25	0.25	5.20	
June	67.2	9.69	6.51	.92	5.99	0.03	0.03	5.96	
July	71.9	9.87	7.10	.94	6.67	0.01	0.01	6.66	
Aug	72.3	9.33	6.74	.92	6.20	0.05	0.05	6.15	
Sept	71.0	8.36	5.93	.80	4.74	0.18	0.18	4.56	
Oct	65.6	7.90	5.18	.72	3.72	0.51	0.51	3.21	
Nov	59.5	7.02	4.18	.54	2.26	1.19	1.13	1.13	
Dec	55.1	6.92	3.81	.35	1.33	2.83	2.55	-1.22	
				Total	40.34				

* From Blaney and Criddle (1).

To provide a method of comparing the results obtained from the Blaney-Criddle analysis to water use at the Santa Ana, California location, information derived from a trial at the U. C. South Coast Field Station, Santa Ana, was used. The Field Station trial, under the direction of Drs. V. B. Youngner and A. W. Marsh was initiated with the objectives of evaluating various irrigation schedules for warm and cool season turfgrass species. The water use data for this discussion were obtained from a particular irrigation treatment that, in turn, were derived from a Bureau of Plant Industries (BPA) evaporation pan.

Table 4 provides a comparison between the estimated water use (Blaney-Criddle U) with that derived from evaportation data at Santa Ana. As can be noted, the two are close. The greatest divergence can be observed in the months of May and June. Interestingly, these are overcast months at the Santa Ana location which could account for high values for the Blaney-Criddle formula. For practical use, both should be corrected for beneficial rainfall.

Table 4. A comparison of turfgrass water need calculated from evaporation at S.C.F.S. (Santa Ana) and the Blaney-Criddle water use estimates.

	Calculated from Evaporation				
Month	1967	1968	1969	Avg.	Blaney-Criddle U
Jan	1.36	1.53	.98	1.29	.90
Feb	2.24	1.30	1.18	1.57	1.43
Mar	2.48	2.88	2.65	2.67	2.62
Apr	2.87	4.39	3.72	3.66	3.73
May	4.87	4.71	3.45	4.34	5.45
June	4.43	5.15	3.35	4.31	5.99
July	6.39	6.10	5.94	6.14	6.67
Aug	6.00	5.96	6.32	6.09	6.20
Sept	4.17	4.72	4.28	4.39	4.74
Oct	4.21	2.98	3.78	3.66	3.72
Nov	1.68	2.05	2.72	2.15	2.26
Dec	1.46	1.46	1.91	1.61	1.33
			Total	41.88	45.04

Because of the close relationship shown between the estimated Blaney-Criddle consumptive use and the evaporation derived water use, individuals in low humidity areas concerned with calculating water use rates on a monthly or yearly basis could consider using the Blaney-Criddle formula. It must be emphasized, however, that the Blaney-Criddle formula <u>is an estimate</u>. Any extensive unnatural conditions such as high winds, long periods of cloud cover, or higher than normal humidity, can, and do, alter the estimated water use rates significantly.

The question then arises, "Is this method of calculating water use applicable to the turf manager who is interested in daily water use figures?" Unfortunately, the most this information can provide is a "ballpark" idea of water use during a particular time of year. As an example, water use rates on a daily basis for the month of January would average .03 to .04 inches whereas for the summer months, use data would indicate an average of .20 to .22 inches per day. Extreme variation from such averages could be expected on a daily basis because of changes in environmental conditions.

Using the above presented information, a turf manager can gain greater insight into his irrigation program. As an example, a cool season grass with a 6-inch effective root system growing on a soil with 1 1/2 inches available water per foot of soil would have the following soil water reservoir:

Water avail./ft. (in inches) x root depth (in feet) = soil water reservoir (in inches).

i.e. 1.5 x 0.5 - 0.75 inches of available water.

If the daily water use is 0.15 inches (March-May in Southern California), then:

$$\frac{\text{Soil water reservoir}}{\text{Water use}} = \text{Irrigation frequency}$$

$$\text{i.e. } \frac{0.75\text{" avail.}}{0.15\text{" day}} = \text{5 day water supply}$$

Of course, the amount of water to be resupplied would be equal to, or slightly greater than, the amount used in that unit time.

There is a method that turf managers can rely upon to more accurately obtain daily use figures. It has been shown from the U.C. South Coast Field Station study that warm season grasses have water use rates approximating 75% of the Bureau of Plant Industries evaporation pan during the winter months and 85% during the late spring, summer, and early autumn months. Water use for cool season grasses approximates 85% of the evaporation readings throughout the year. The following table provides an example in this regard.

Table 5. The relationship between a BPI evaporation reading and water use for warm and cool season turfgrasses.

BPI evaporation reading per unit time	Inches Water Use		
	Warm Season Grasses		Cool Season Grasses
	Winter	Summer	All Year
1 inch	.75	.85	.85

With this relationship in mind, turf managers who want a more precise understanding of daily turfgrass water use under their environmental conditions can install a Bureau of Plant Industries pan to obtain the needed information.

Conclusion

Proper turfgrass irrigation, like other aspects of turf management, is the combining of science and art. Like any science, the important factors must be segmented into recognizable parts that are comprehended. Like any art, the end product results from a vision and a working understanding of the media.

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NOTE: This information was initially reported in the 10th Annual Proceedings of the Turfgrass Sprinkler Irrigation Conference, June 16-18, 1972.

Discussion Period

Dr. Wilkinson: On those small irrigation plots, with the different tensiometer treatments, how were you able to get uniform water distribution on a windy day?

Dr. Gibeault: Generally, the wind conditions at Santa Ana are not all that bad. On a daily basis, the plots were irrigated in the early morning hours, (between six and eight) when the wind conditions were fairly calm. The plot location itself is situated in an old citrus area. It is common, in Southern California, to have eucalyptus wind breaks which surround such areas. So, wind conditions were not a problem. In observing the plots there was little indication of poor distribution.

Dr. Fushtey: How important is time of day with respect to supplying water to turf?

Dr. Gibeault: As a general recommendation, the early morning hours near sunrise would be the best irrigation time on a daily basis. But, of course, this can differ based on wind patterns or use of a particular area. This allows the surfaces to dry as rapidly after irrigation and reduces possible disease complications.

Dr. White: Would you share with us your thoughts on syringing turf in the dry areas of the country.

Dr. Gibeault: It is done, mainly for temperature control; when annual bluegrass is of predominant cover in areas of high summer temperatures. Personally, I can't say the practice is good or bad. It depends on the situation. If a facility has annual bluegrass and the manager is concerned about losing it, then it is best to syringe.

Mr. Countryman: Do you have the problem of salinity in your irrigation water and do you take this into account during your irrigations?

Dr. Gibeault: Generally, it is not a major problem. Water from the Colorado River has an EC of 0.75 to 0.90 indicating about 500 to 500 parts per million salts. Under normal irrigation practices there are no problems with this water. If, however, you have layered soils, which prevent the water from percolating or if enough water is not being applied to leach the salts, then salts accumulate within that root profile which can cause serious problems. Under general conditions in California, I do not think we have major salinity problems.

WEED CONTROL WITH HERBICIDES IN WARM SEASON TURF

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Introduction

Weed control with herbicides in warm season turf is rather complex primarily due to the number of species and cultivars. There are at least six turfgrasses that are used in the Southern United States; bahiagrass (Paspalum notatum Flugge), bermudagrass (Cynodon dactylon (L.) Pers.), carpetgrass (Axonopus offinis Chase), centipedegrass (Eremochloa ophiuroides (Munro) Hack.), St. Augustinegrass (Stenotaphrum secundatum (Walt.) Kuntze), and zoysiagrass (Zoysia japonicia Stend., Zoysia matrella (L.) Mers., and Zoysia japonica x Z. tenuifolia, Willd. ex Trin. In terms of acreage, carpetgrass and bahiagrass are the least important of these six turfgrasses. These two grasses and Dichondra (Dichondra repens Forst.) are often weed problems in bermudagrass, zoysiagrass, centipedegrass, and St. Augustinegrass. The use of dichondra for turf is generally limited to areas that are consistently irrigated in the Southwestern United States. Dichondra is almost exclusively considered a weed in the Southeastern United States.

In the Southern United States limited acreages of the annual and perennial grasses are overseeded for green color during the dormant season. These are used to overseed lawns, fairways or golf putting greens. Five species are commonly used as monostands or as mixtures for golf putting greens; annual ryegrass (Lolium multiflorum Lam.), Perennial ryegrass (Lolium perenne L.), rough bluegrass (Poa trivialis L.), creeping bentgrass (Agrostis palustris Huds.), and Creeping red fescue (Festuca rubra L.). Annual ryegrass is most often used on lawns or fairways.

Weed Control in Overseeded Warm Season Turf

Weed control recommendations for cool season grasses overseeded into dormant warm-season turf are certainly limited. The small acreage involved has not created a demand for the expenditure of large amounts of time and money for research at agricultural experiment stations. Secondly, the label status of many herbicides, due primarily to the susceptibility of germinating or very young turfgrass plants, limits the usable herbicides available (Jagschitz and Skogley, 1965, Bingham et. al. 1969).

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The approach used on overseeded golf greens which accounts for a very high percentage of overseeding, appears to employ timing of application, repeated applications of reduced rates, or selection of materials with less phytotoxicity to young grasses.

Annual bluegrass (Poa annua L.) is the only monocot that is a serious weed problem throughout the Southern United States during the dormant season. Control of this weed in overseeded turf must be accomplished prior to overseeding. No herbicide has yet been found that will selectively control annual bluegrass in the species presently used to overseed golf greens. The approach used by many golf superintendents is to apply bensulide (O, O-diisopropyl phosphorodithoate S-ester with N-(2-mercaptoethyl) benzenesulfonamide) prior to overseeding. We find that many of the superintendents are making application of bensulide 60 days prior to overseeding. Label directions indicate that there should be a 90-day waiting period. Bensulide is the only one of the three major preemergence herbicides that is labeled to use on putting greens. DCPA (dimethyl tetrachloroterephthalate) and benefin (N-butyl-N-ethyl-a, a, a-trifluoro-2, 6-dinitro-p-toluidine) are possibly being used to a very limited extent although these are not labeled for use on greens by the basic developers of these products.

Preemergence application to overseeded grasses 3 to 4 months after late fall seeding can result in reductions in density and quality of the overseeded turf (Figure 1). Under most conditions, rough bluegrass and annual ryegrass, are too susceptible to preemergence herbicides for safe use (Coats et. al. 1973). Although annual bluegrass continues to germinate throughout the winter, the best approach is to use bensulide prior to overseeding and then depend on grass competition to control annual bluegrass as much as possible during the winter months.

Broadleaf weed problems in overseeded turf are quite variable. A number of the common winter annual broadleaved weeds found throughout the Southern United States during the dormant season may or may not be a problem in overseeded turf. Competition from the overseeded turf often significantly reduces these infestations. Henbit (Lamium amplexicaule L.), common chickweed (Stellaria media (L.) Cyrillo), clovers (Trifolium spp), spurweed (Soliva pterospermia (Jussieu) Sc.), mustards (Brassica spp.) and sheperdspurse (Capsella bursa-pastoris (L.) Medic) are among the more important of this group. However, it is usually henbit, common chickweed or clover that dictates the selection of a herbicide program. These weeds are usually fairly tolerant of 2,4-D (2,4-dichlorophenoxy) acetic acid necessitating the use of other "phenoxy type" materials (Klingman and Shaw, 1972). In general, silvex 2-(2,4,5-trichlorophenoxy) propionic acid, dicamba (3,6-dichloro-o-anisic acid), or a phenoxy-dicamba mixture are recommended for broadleaf control where these three weeds are present. Weed-B-Gon, a mixture of mecoprop 2-(4-chloro-o-tolyl)oxy propionic acid and chlorflurenol (methyl 2-chloro-9-hydroxyfluorene-9-carboxylate), is also used to some extent on St. Augustinegrass. Dicamba or dicamba mixtures appear to be the most widely used in this situation since silvex is fairly phytotoxic to overseeded species. There are numerous dicamba-phenoxy (2,4-D) formulations on the market. These and the 3-way mixtures of 3D Weedone (2,4-D + silvex + dicamba) and Trex-San or Trimec (2,4-D + mecoprop + dicamba) are probably used more by homeowners than dicamba alone.

Weed Control in Established Warm Season Turf

Comments in this section will be restricted mainly to control of weeds in bermudagrass, centipedegrass, St. Augustinegrass, and zoysiagrass. The four species vary in their susceptibility to both preemergence and postemergence herbicides. However, it is possible in most cases to discuss bermudagrass and zoysiagrass separately from centipedegrass and St. Augustinegrass. In general, herbicides that can be used on bermudagrass can be used safely on zoysiagrass. Centipedegrass and St. Augustinegrass are similar in their tolerance to herbicides.

Weed problems in southern turf occur both in the growing and dormant seasons. Weedy plants are both annual and perennial.

Winter Grass Weeds - Annual bluegrass is by far the most severe grassy weed infesting southern turf areas during the late growing season through the dormant period and into the early growing season. Aside from decreasing the aesthetic value of turf, the primary objection of annual bluegrass in southern turf is the weed problems that are associated with the rapid die-back in late spring. Bermudagrass coverage is usually slow following fade out of annual bluegrass leaving large areas of the soil surface exposed. This in itself is not as objectionable as the weeds that tend to germinate in these bare areas. Goosegrass (*Eleusine indica* (L.) Gaertn.) which is usually very difficult to control, is one of the most serious invaders.

Annual bluegrass control with preemergence herbicides is usually accomplished with either benefin, bensulide, DCPA, or terbutol (2,6-di-tert-butyl-*p*-tolyl methylcarbamate). Two applications of these materials may be necessary during the dormant season for acceptable control.

Pronamide (3,5-dichloro (N-1,1-dimethyl-2-propynyl)benzamide) is a newer material that has shown excellent potential for either preemergence or postemergence control of annual bluegrass in bermudagrass (Coats, 1974; Horn, *et. al.*). Our results in Mississippi indicate that application made as early as November and as late as April will give control. However, we feel treatment should be made prior to seed production to reduce next year's seed supply. Application prior to seeding is also early enough for annual bluegrass to be controlled and not interfere with transition of the bermudagrass.

A third approach employed particularly on many golf courses is to use a postemergence application of a non-selective herbicide such as paraquat (1,1'-dimethyl-4,4-bipyridinium ion) or cacodylic acid (hydroxydimethylarsine oxide) prior to breaking of dormancy. This usually does an excellent job on annual bluegrass as well as those annual broadleaved weeds present. Injury is often encountered if application is delayed until the bermudagrass starts breaking dormancy. The degree of injury is dependent on the amount of green foliage present at the time of application.

Winter Broadleaved Weeds - Important broadleaved weed species include: common chickweed, henbit, clovers, spurweed, mouseear chickweed (*Cerastium vulgatum* L.), lawn burweed (*Soliva nasturtifolia* (Jussieu) DC.), common dandelion (*Taraxacum officinale* Weber), wild onion (*Allium canadense* L.), wild garlic (*Allium vineale* L.), plaintains (*Plantago* spp), and speedwells (*Veronica* spp).

Preemergence control with benefin, bensulide, DCPA, and other herbicides is not used on a large scale for control of winter broadleaved weeds. As previously discussed henbit, chickweed, and clovers are most efficiently controlled with something other than 2,4-D. In dormant bermudagrass and zoysiagrass, silvex, dicamba, or a combination containing dicamba are usually used. It is our observation that golf course superintendents or commercial applicators are generally using silvex, dicamba, or 2,4-D plus dicamba. Homeowner use of specific herbicides is highly dependent on the availability of the products in the marketplace. The phenoxy herbicides are safe on completely dormant turfs. Actively growing turfs vary considerably in their tolerance to phenoxy type materials (Table 1, Winstead, 1969). St. Augustinegrass will usually tolerate a 1/2 lb. AI/A of 2,4-D with only minimal injury. At rates above 1/2 lb. AI/A St. Augustinegrass is usually injured. St. Augustinegrass and several bermudagrasses are also quite susceptible to injury by silvex. This may seem unimportant when using phenoxy on dormant warm season turfs but invariable application is made at various stages during spring transition. It is consistently observed that all warm season turfgrasses are more susceptible to phenoxy injury during this transition period. The combination of mecoprop plus chlorflurenol is often used, especially by the homeowners.

Summer Grass and Sedge Weeds - Hairy crabgrass (*Digitaria sanguinalis* (L) Scop.) and dallisgrass (*Paspalum dilatatum* Poir.) invade more turf acreage in the Southern United States than any other grasses. Germinating seeds of both can be satisfactorily controlled with benefin, bensulide, DCPA, atrazine

(2-chloro-4-(ethylamino)-6-(isopropylamino)-2-triazine), and (simazine 2-chloro-4, 6-bis(ethylamino)-2-triazine). Certain formulations of atrazine and simazine are labeled for use on St. Augustinegrass, zoysiagrass, and centipedegrass for sod production while other commercial products containing atrazine and simazine are labeled for homeowner use.

Postemergence control of hairy crabgrass and dallisgrass in St. Augustinegrass and centipedegrass cannot be accomplished with the herbicides presently available. In bermudagrass and zoysiagrass, MSMA (monosodium methanearsonate) and DSMA (disodium methanearsonate) are effective. In fact, dallisgrass control is accomplished almost exclusively in bermudagrass and zoysiagrass with the arsonates.

In terms of difficulty of control, goosegrass is the number one summer grass problem in the Southern United States. Control of goosegrass is at best erratic. Timing of application of preemergence herbicides is of paramount importance if control is to be achieved. In our area (latitude 35 N) we generally think goosegrass starts germinating in significant quantities around May 1-15. However, this can and does vary by several weeks. If application of a preemergence herbicide is delayed, generally large crabgrass will not be controlled because it germinates earlier than goosegrass. In bermudagrass and zoysiagrass, large crabgrass can be controlled quite effectively with postemergence applications of the arsonate herbicides. The use of preemergence herbicides appears to be a better approach to goosegrass control than postemergence control with arsonates. With the drastically increasing price of arsenical herbicides and the tolerance of goosegrass beyond the juvenile stage, the postemergence approach is becoming much less attractive. Additional research on goosegrass control is drastically needed.

Other grass weed problems in southern turf include sandbur (*Cenchrus* spp), bahiagrass, crowfootgrass (*Dactyloctenium aegyptium* (L.) Richter), torpedograss (*Panicum repens* L.) and others. Sandbur and bahiagrass can be controlled with arsenicals. No means of selective control of torpedograss in any southern turf species has been developed at the present time.

Both annual and perennial sedges are problems in the Southern United States. Purple nutsedge (*Cyperus rotundus* L.) and to a lesser extent yellow nutsedge (*Cyperus esculenthus* L.) are the most severe problems. Multiple applications of arsenicals or an arsenical plus a phenoxy are generally recommended at the present time. Successful control is dependent on repeated applications at appropriate intervals. This is the only method commonly used for selective control in warm-season turf and can be used only on bermudagrass and zoysiagrass.

There are several materials in the developmental stage that show some potential for selective control of these perennial nutsedges; bentazon (3-isopropyl-1H-2,a,3-benzothiadiazin-(4)3H-one 2,2-dioxide), perfluidon (1,1,1-trifluoro-N-(2-methyl-4-(phenysulfonyl) phenyl methanesulfonamide), and (S-21634(1,(methyl-4-phenylpyridinum chloride, Gulf Oil). Glyphosate (N-(phosphonomethyl)glycine) is apparently phytotoxic to all turfgrass but does have potential as a site preparation aid. Hopefully, one or more of these compounds will eventually be developed for turf and provide a better means of nutsedge control than presently available herbicides.

Summer Broadleaved Weeds - Broadleaved weeds are a problem in turf throughout the Southern United States. However, no single species would appear to reach the level of infestation over large areas equivalent to that observed with hairy crabgrass, dallisgrass or goosegrass. Among the more important broadleaved weeds are prostrate spurge (*Euphorbia supina* Raf.), prostrate knotweed (*Polygonum aviculare* L.), woodsorrel (*Oxalis* spp), pennywort (*Hydrocotyle* spp), ground ivy (*Glechoma hederacea* L.), creeping Charlie (*Lysimachia mummularia* L.), and Florida betony (*Stachys floridana* Shuttlew). As a group, these are rather difficult to control. Multiple applications of dicamba, silvex and 2,4-D are almost always necessary. It is generally observed that the use of a good agricultural grade nonionic surfactant will increase control of these weeds. (See discussion period after next paper).

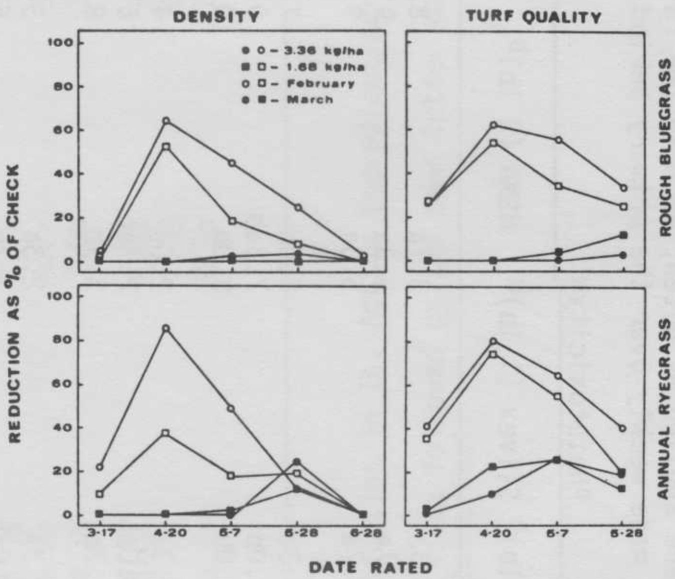

Figure 1. The effect of benefin applied on February 18 and March 17 on the density and turf quality of annual ryegrass and rough bluegrass. Data represent percentage reduction of turf quality or density as compared to the untreated check and are the average of five replications. (Coats et al., 1973)

Table 1. Phytotoxicity of herbicides to established Southern turf (From Winstead, 1969). Materials were applied as noted, once in the fall and twice in the spring after green-up. Ratings were made weekly over the primary period of injury.

		Phytotoxicity[a]				
Turf	Rate	2,4-D (1 lb)[b]	Dicamba (1/2 lb)[b]	Silvex (1 lb)[b]	MSMA (2 lb)[b]	DSMA (5 lb)[b]
Centipede grass	1x	2.3a	3.3a	3.7a	8.3a	8.3a
	2x	2.3a	3.7a	3.3a	9.3a	8.7a
	4x	3.7a	4.7a	5.0a	9.7a	9.7a
St. Augustine grass	1x	4.7a	3.3a	6.0a	7.7a	7.7a
	2x	5.7ab	5.0b	7.3ab	9.7b	9.3b
	4x	6.3ab	6.0b	8.0b	10.0b	10.0b
Emerald Zoysia	1x	1.7a	2.3a	2.0a	4.3a	4.3a
	2x	2.0a	3.0ab	2.3ab	6.3b	5.7b
	4x	2.7a	3.7b	3.3b	8.7c	8.7c
Meyer Zoysia	1x	2.3a	2.3a	2.3a	3.0a	3.3a
	2x	2.7a	3.0ab	3.3b	5.3b	5.3b
	4x	3.0a	3.3b	4.3c	7.7c	7.7c
Tifdwarf Bermuda	1x	4.3a	4.7a	5.7a	3.7a	4.0a
	2x	5.3b	6.3b	8.3b	4.7b	5.0b
	4x	6.3c	7.3c	10.0c	6.7c	7.3c
Tifgreen Bermuda	1x	3.7a	3.7a	5.3a	3.3a	3.7a
	2x	4.3ab	5.0b	7.7b	4.7b	5.0b
	4x	5.3b	6.3c	9.3c	6.3c	7.0c

Table 1 Cont.

Tifway Bermuda	1x	2.7a	3.0a	3.7a	3.3a	4.0a
	2x	3.3ab	3.3a	4.7a	5.0b	6.0b
	4x	4.3b	4.3a	7.0b	7.0c	8.3c
Common Bermuda	1x	2.3a	3.0a	4.3a	4.3a	4.7a
	2x	3.7ab	2.7a	7.0b	6.0ab	6.3a
	4x	5.0b	3.7a	9.7c	7.7b	8.7b

[a]0 to 10 scale-0 no injury and 10 complete top kill.

[b]Values in parentheses represent the 1x rate of application in lb. Active Ingredient/Acre.

[c]Within herbicide columns and within species only a value followed by the same letter does not differ significantly at the 5% level according to Duncan's new Multiple Range Test.

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HERBICIDES FOR COOL SEASON GRASSES

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Woe...Woe...Woe... What will we have to throw at weeds? Control officials have taken this; they have taken that. No longer is this and that label valid.

Not yet. We have not lost the battle with EPA, but there are scars already. There have been several decisions which some of us would question, including earlier 2,4,5-T. However, some decisions not made as yet are equally important.

The bright star on the horizon is Roundup, or glyphosate. It offers unique possibilities for clean-up where everything should be removed, but from the turf research standpoint, glyphosate offers the wide possibility of replacing the so-so turf, junk, or even old standard varieties with newer improved cultivars.

For example, currently in Indiana, 20 bluegrass cultivars may be sold. Within these, there is wide possibility so, fortunately, today we are able to discard the second place much easier than in former times, for there are superior replacements available.

Another bright star now with us is the continued acceptability of the use of a broad spectrum herbicide application. For example, several companies merchandise mixtures of 2,4-D, mecoprop, and dicamba. Others have similar formulations designed to kill both viney and broadleaf weeds. Technology now with us indicates that we can expect more caution in the rate of use and more control in the kind of use.

The Mid-Atlantic Newsletter, Volume 25, No. 6, June 1974 points out that there are ten professional classes of pesticide applicators, according to EPA. Yet golf courses are not even mentioned. Further, this article points out some of the present problems facing golf course superintendents.

We, in this group, have an opportunity to make a concerted effort towards achieving identity of golf course superintendents and their placement into a category that is logical and livable. It is my recommendation that golf course superintendents be a representative of the owner. Therefore, he is a private applicator just as a farm manager represents a farm owner. Thus on that farm he may apply as a private applicator those things pertinent to his agricultural enterprise. Now, when a golf course superintendent moves outside that assigned responsibility he would logically be a commercial applicator working for a fee and subject to regulations of a custom applicator.

How can we make such an opinion heard where it counts? Perhaps this is the challenge for this educational group.

We are blessed with several crabgrass preventers which have served the industry well, both for homeowner and professional. The more recent problem of limited availability of calcium arsenate does cause numerous programs under way, wherein calcium arsenate is applied for toxicity to Poa annua, to have concern for professional turf areas. Some superintendents have sold their materials to others. Some have hoarded what could be bought. Some are uncertain.

Adding to this dilemma is the limitation in fertilizer availability so that some turf managers have purchased low phosphorus fertilizer to get nitrogen which will affect their arsenic toxicity. Some have wisely gone into a holding program for a period to see if some form of calcium arsenate will yet be available for Poa annua, crabgrass, and insect control program.

I am personally encouraged in 1974 by the renewed effort by companies to have wider testing and wider observations of chemicals and formulations. This seems to me a sign of financial health, a sign of progress, and continued upgrading in the herbicides to be made available.

So, herbicides for cool season grasses are somewhat marking time. Unfortunately, turf is such a minor user of products that there may be real question for future development of products just for the turf business. This is a cause for concern.

Discussion Period

Dr. Schmidt: Euel, does glyphosate or paraquat have a longer residual life in turf with a deep thatch layer?

Dr. Coats: No, I have not noticed any differences in activity due to degree of thatchiness.

Dr. Schmidt: Are you presently working with glyphosate or paraquat?

Dr. Coats: Glyphosate. We are using glyphosate for the first time this year. When applied to bermudagrass which was 90 to 95% dormant, glyphosate delayed its green-up by at least six weeks.

Dr. Halisky: Euel, you mentioned that some of the herbicides increased the susceptibility to brown patch and pythium on bentgrass. Would you please comment on that?

Dr. Coats: I mentioned some long range studies, being conducted by Dr. Lloyd Callahan of the University of Tennessee. He found increased susceptibility of bentgrass to these diseases following repeated applications of herbicide over a 3 or 4 year period.

Dr. Whitworth: You observed injury on Tifgreen bermudagrass from Dacthal. Did you observe similar injury on Tifway bermudagrass?

Dr. Coats: Yes, we had it on Tifway, and some other bermudagrasses. However, Tifgreen is the only one which we have studied in detail. I might comment that we have never particularly noticed this where the grass was mowed at one inch or higher. It was noticeable only when we lower the height of cut of Tifgreen to stress conditions of putting greens.

Dr. Whitworth: We are also having a good deal of trouble with this variety of bermudagrass in New Mexico. One other question, can you control nutsedge postemerge with Destin?

Dr. Coats: No, Destin works by inhibiting the germination of the tubers, while the Gulf material gives postemerge activity.

Dr. Whitworth: Under natural conditions other than when you infested it?

Dr. Coats: Yes.

Dr. Lee: I would like to address this question to Dr. Bill Daniel. What rates of glyphosate are effective for quackgrass control here in the Midwest? In our Rocky Mountain region under rather dry conditions and low humidity, it requires from 3 to 4 pounds of glyphosate to be effective. What rates do you use here in the Midwest?

Dr. Daniel: I believe we tested rates from 1 to 10 pounds/per/acre with three pounds being adequate. Most of the time two pounds was a satisfactory rate. One minor problem with quackgrass in an old stand is that often a few detached rhizomes are present at the time of treatment, so reinfestation will occur from these and re-treatment will be needed.

Dr. Kinbacher: Back to nutsedge control with this Gulf product and Destin. Can these be used under trees and around shrubs?

Dr. Coats: You can expect some injury. We have been testing these herbicides on 26 ornamentals in the greenhouse. A growth abnormality that looks something like the phenoxy injury is evident. We first observed this kind of injury in the field on Ligustrum leaf tips. A typical symptom was the fusing of adjacent leaftips, at least they were stuck together enough that you couldn't pull them apart. This abnormality is only temporary. Liquid formulations were more phytotoxic than granules.

Dr. Hall: Euel, have you noted any phytotoxicity from betasan applied to zoysiagrass at the time of green-up?

Dr. Coats: No, but I haven't really looked for it. Our research is mostly with bermudagrass.

Dr. Duble: I would like to ask Bill Daniel in the absence of tricalcium arsenate what do you recommend for *Poa annua* control in bentgrass greens?

Dr. Daniel: Not much. Elanco does not recommend Balan on golf greens. Of course, it would work but again you have a label problem and a guarantee problem. Betasan is quite safe. The residual is not as long. To answer you briefly, if you are using one of the standard pre-emerge materials, apply it in the first part of August at "the label" rate then reapply in late fall to build up your residual to go through the winter and through the wet early spring when *Poa annua* gets ahead of everything. Treat again in late spring for crabgrass, touch up again in late fall and cross your fingers. That would be my suggestion. May I comment further answering you. I was half kidding when I said "cross your fingers". I meant timing is so critical and toxic concentration is so variable that continuous prevention of *Poa annua* infestation is difficult. That is what I meant by "cross your fingers".

Dr. Turgeon: Dr. Halisky had a question earlier regarding the relationship of herbicide application and disease incidence. We have data to show increased susceptibility to stripe smut disease following several applications of Bandane in Michigan and in Illinois. Bandane induced higher susceptibility to leafspot disease as did calcium arsonate. Thatch was a problem and could have been a pre-disposing factor to the disease, rather than the herbicide. Another thing I want to point out concerns the mammalian toxicity of the Gulf compound, S216. Its LD50 is about 74 mg/kg dermal and about 27 mg/kg oral, which to me would limit its practical use considerably.

Dr. Huffine: I would like to direct this question to Dr. Coats. Did I understand you to say that you were observing some damage to bermudagrass from dormant application of glyphosate?

Dr. Coats: The grass was not completely dormant; there was some green foliage.

Dr. Huffine: OK. But if it's completely dormant, you have had no problem?

Dr. Coats: That is correct.

Dr. Mazur: Euel, have you used Kerb prior to overseeding?

Dr. Coats: No, but I believe there has been some work done with it in Florida. Dr. Dudeck, would you like to comment on that?

Dr. Dudeck: Yes, we have conducted studies on the use of Kerb prior to overseeding. Based on these studies we recommend a waiting period of 60 days between the application of Kerb and overseeding. We can reduce this period to 30 days prior to overseeding, if we deactivate the Kerb with activated charcoal.

WHAT'S NEW IN TURFGRASS FUNGICIDES

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Systemic Fungicides

One cannot talk about what is new in turfgrass fungicides without immediately thinking of the systemic fungicides. For those of you not familiar with the systemic fungicides or how they act, they are fungicides which are absorbed by the plant and then translocated upwardly, at least the ones we presently have are only translocated in one direction, where they can prevent infection from occurring. Notice I said prevent infection from occurring; for the systemic fungicides are basically fungistatic, that is, they prevent the fungus from germinating and/or growing but do not kill the fungus.

There are four systemic fungicides on the market today. They are: benomyl, sold as Tersan 1991 and ProTurf Fertilizer Plus DSB; thiophanate-methyl, sold as Spot Kleen and Fungo; thiophanate, sold as Cleary's 3336; and thiabendazole, sold as Mertect 140. Of these four fungicides, benomyl and thiophanate-methyl convert to the same active ingredient benzimidazole carbamate methyl ester (BCM). Thiophanate converts to a related compound benzemidazole carbamate ethyl ester (BCE). This means that all these fungicides have the same action spectrum and the only difference among them being their ability to convert to BCM or BCE under various environmental conditions. Thiabendazole does not convert to BCM or EBC but does have an action spectrum similar to the other three. From a practical point of view it actually has a much more limited action spectrum because it is phytotoxic and cannot be used against diseases like brown patch, *Fusarium* blight and stripe smut which require two or more oz/1000 sq. ft. for their control.

What Diseases do the Systemic Fungicides Control?

The systemic fungicides give excellent control of *Sclerotinia* dollar spot (*Sclerotinia homeocarpa*) (Massie and Cole 1969; Goldberg, Cole and Duitch 1970 a & b; Vargas, Beard, and Detweiler 1973). Six (6) weeks control with as low as 1 oz/1000 sq. ft. has been shown by Vargas et. al., 1973. To get this control the systemics should be applied with 10 to 20 gallons of water or else watered in immediately after application before it dries on the foliage. This will get the fungicides into the crowns and roots of the grass plant where it can be translocated upward and into new leaf tissue as it arises.

The systemic fungicides are the only fungicides which will control Fusarium blight caused by Fusarium roseum and Fusarium tricinctum (Vargas & Laughlin, 1971; Muse, 1971) with nematodes also being shown to be involved in the disease in Michigan (Vargas & Laughlin, 1972). To be effective the systemic fungicides benomyl, thiophanate-methyl and thiophanate must be drenched into the root zone immediately after application (Vargas & Laughlin, 1971). It is also advisable to irrigate the area to be treated the night before.

The systemic fungicides (Cole, Massie, Duitch, 1970; Jackson, 1970; Vargas, 1972), along with PCNB and fertilizer (Halisky, Frink, and Babinski, 1969) have been shown to be effective against stripe smut. Our best results have been obtained with 8 oz/1000 sq. ft. of benomyl, thiophanate-methyl and thiophanate application being followed by an application of ProTurf Fertilizer Plus PCNB. We feel the ProTurf Fertilizer Plus PCNB helps control the increased Helminthosporium incidence in Kentucky bluegrass (Poa pratensis L.) caused by stripe smut infection and/or benzimidazole systemic fungicide treatment. The fertilizer in the combination apparently counteracts the mild phytotoxicity PCNB causes to the grass. As with Fusarium blight the systemic fungicides must be drenched in immediately after application before they dry on the foliage and irrigating the area the night before is also desirable. The best results are obtained when the treatments are applied in the late fall after the grass goes dormant or early spring before the grass breaks dormancy (Cole et. al. 1970 and Jackson, 1970).

Gould, Goss and Miller (1972) have observed severe outbreaks of Helminthosporium where only the systemic fungicides were used for the control of Fusarium patch (pink snow mold) caused by Fusarium nivale. They found that the best results were obtained by alternating applications of systemic fungicides with contact fungicides like Fore.

Resistance to the systemic fungicides has developed rapidly. Vargas (1973) reported resistance to powdery mildew and (Vargas, 1973) to Sclerotinia dollar spot as did Goldberg and Cole, 1973. This has occurred primarily where the systemic fungicides were used on an exclusive basis. That is where the systemic fungicides were the only fungicides in the spray program for controlling Sclerotinia dollar spot. Since all the systemic fungicides have a similar mode of action, resistance to one has meant resistance to all. This, of course, can be avoided by using good contacts like Dyrene, Acti-dione-thiram, Daconil 2787 or ProTurf Fungicide III.

Diseases Not Controlled by the Systemic Fungicide

Helminthosporium disease and Pythium blight are diseases that the systemic fungicides will not control, and they are only fair against brown patch (Rhizoctonia solani). I point this out only because all the systemic fungicides carry brown patch control on their label and they simply won't hold up under severe or prolonged disease pressure. In addition some also contain Pythium blight and/or Helminthosporium disease control on their label and they won't work at all on these diseases.

Other New Fungicides

It has only been the last five or six years that we have had fungicides which would give excellent control of one of the worst turfgrass diseases - Pythium blight. The two fungicides which will do this are chloroneb (Wells, 1969) sold as Tersan SP, and ProTurf Fungicide II, and terrazole, sold as Koban. And while we now take Pythium blight control as routine it wasn't that long ago that golf course superintendents had to simply sit by, or use some less-than-adequate fungicides, while the grass was disappearing during the hot humid weather from a Pythium blight attack.

Perhaps no turfgrass disease has gotten the attention in Washington, D.C. that Typhula blight (gray snow mold) has over the cancellation of the mercuries and at the time of this writing the question of mercury fungicide cancellation is still unresolved. Fortunately, during this time chloroneb was found to give excellent control of Typhula blight. It was shown to give as good a control of Typhula blight as the most effective mercury fungicide, a granular formulation of mercuric and mercurous chloride, sold as Calo Gran (Vargas & Beard, 1970). Vargas & Beard (1971) also showed that these fungicides could be applied after the mowing and still give excellent control. This greatly extends the safety margin for applying snow mold fungicide treatments in areas of permanent snow cover for periods of 3 or more months. In this study the granular chloroneb was superior to the wettable powder formulation (Vargas & Beard, 1970 & 1971).

The use of chloroneb has also done away with the subtle phytotoxicity problem observed with the mercuries. This phytotoxicity was assumed by many superintendents in the more northern regions of North America be to the lack of nitrogen response during the cool weather of spring and fall. The use of chloroneb has shown this lack of nitrogen response to be nothing more than a mild case of mercury phytotoxicity (Vargas & Beard, 1970 & 1971).

The past couple of seasons have also shown Pentachloronitrogenzene (PCNB), sold as Terraclor, ProTurf Fertilizer Plus PCNB, and Acti-dione-RZ also give excellent control of this disease. However, PCNB does have a phytotoxicity on some bentgrass cultivars. PCNB does not appear to be phytotoxic on the cultivar "Penncross" but is phytotoxic on the cultivar "Cohansey" (C-7). Toxicity on other cultivars need to be evaluated before recommendations can be made.

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Discussion Period

Mr. O'Knefski: Joe, Dr. Richard Smiley, our turfgrass pathologist on Long Island has been observing plots he treated with an application of systemic fungicide last summer and early fall. This year, during late spring and early summer he has noticed some discoloration or "injury" on those plots. Have you observed this and do you know the cause?

Dr. Vargas: We have not observed injury per se but if you look at the Merion Kentucky Bluegrass which has been treated with a systemic fungicide, it has the very large Helminthosporium lesions on it and we feel that most of that off coloring is simply due to the leaf spot infection. Has anybody else observed this?

Dr. Halisky: I wonder if you would comment about fairy rings?

Dr. Vargas: My personal opinion about fairy rings is that you ought to learn to like them, or else dig them out, or fumigate them. My personal experience with drilling holes and pouring mercury and Captan or anything else down there has displaced them a little bit or sometimes break the one large fairy ring into little ones, but if you want to get rid of them, you have got to dig them out or else till the soil and fumigate with something like methylbromide.

Dr. Newman: Joe, does benomyl work equally as well with all cultivars of *Poa pratensis* that end up with *Fusarium roseum*.

Dr. Vargas: I can only fathom a guess. We have only worked on Merion Kentucky Bluegrass but it is my belief that if you have got Fusarium blight in Fylking or Pennstar you are going to have a very difficult time controlling it even with benomyl. They seem to be extremely susceptible to the disease; a lot more so than Merion.

Dr. Halisky: I want to go back to your statements on the combination materials for stripe smut. It would seem to me that PCNB, which is an exceptionally good chemical for controlling Helminthosporium melting-out in bluegrass, would be good for combination with a systemic. Some of the research we did at Rutgers 6-8 years ago indicated PCNB was very good not only for Helminthosporium but also for stripe smut.

Dr. Vargas: This year we had it (PCNB) in a replicated study for stripe smut. We did get some reduction but it wasn't significant. However, we had two home lawns treated in May and September and they have taken care of their stripe smut problems by this fertilizer-PCNB combination. Again it wasn't a replicated sutdy but the lawn originally had quiate a lot of disease in it. The neighbor's lawn still had the problem and the experimental lawns did not. So I do believe that PCNB will control stripe smut. At least prevent new infection.

Dr. Martin: Yellow spots have been observed on various bentgrass cultivars. Have you worked with what the cause of this is and its control?

Dr. Vargas: No, I haven't worked with it and I don't know what the control is. I heard the other day that Noel Jackson is working on it.

Dr. Duff: Joe, would you elaborate on the use of EL273 for control of powdery mildew? Rates, time of application and so forth.

Dr. Vargas: We started in June and as low as 2 ounces of material and obtained six to eight weeks of control.

Mr. O'Knefski: I just wondered if you would like to comment on your plots that you have with Fusarium and in combination with nematodes. I believe you did a study with nematodes in relations to Fusarium and the fungicides.

Dr. Vargas: We feel in Michigan at least, and perhaps we are far enough North that we need an additional stress, that where we have the symptoms from Fusarium blight developing, we have high populations of nematodes particularly the stunt nematode and the ring nematode. I didn't want to get into that, but I did anticipate that question. There is oxamyl or vydate, the best nematocide we found. Another good one has been dasanit. We've had some success with nemacur. In one trial nemacur will look excellent but, in the next, it doesn't. Dr. Herb Cole at Penn State said they don't find any control in Pennsylvania with nematocides and I'm getting to the point where I'm becoming paranoid and staying awake at night trying to figure out "how come" and "why". We are going back at it again this year. Again, maybe it is because we are so far north that we don't have those prolonged periods of high temperatures like they have in the more southern areas and need the additional stress from the nematodes for symptom development.

Dr. Ensign: Joe, do you have locations up there where you have predominately Typhula and other places where you only have Fusarium or do you have complexes of the two?

Dr. Vargas: Yes, the farther north we go the more Typhula we have. The farther south in general, the more Fusarium. But then you get into a species reaction where the bentgrasses have the Typhula on them, even in the south, and the annual bluegrass and Kentucky bluegrasses that have the pink snowmold (Fusarium) on them even in the north.

TURFGRASS SEED LABELING

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Introduction

I am here at the invitation of Scotts and represent the American Association of Seed Control Officials and as the Chairman of its Joint Legislative Committee which is comprised of four members each of the American Seed Trade Association, Association of Official Seed Analysts, Association of Official Seed Certifying Agencies, and the American Association of Seed Control Officials. Its main purpose is to identify regulator needs and to formulate rules and regulations dealing with the growing, processing, testing and marketing of seeds. Its voice is the recommended State Seed Law which is a basis where all states and the Federal Government may turn to in updating their seed laws. Turfgrass seed labeling is just one of the many problems this Committee is trying to solve. I was appointed to the Chairmanship of this important Committee in September 1973 after serving as a member for four years.

Joint Legislative Committee

One of the biggest problems this Committee faces is that it meets every two years at the biennial meeting of the AASCO. It was felt by the AASCO, Legislative Committee, and the Subcommittee on turfgrass seed labeling that perhaps the process could be speeded up by conducting a written survey of all states on turfgrass seed labeling. The following letter was sent to each state:

"The Legislative Committee and Subcommittee on Turfgrass Seed Labeling have worked on solutions to this problem for over ten years and we are far from obtaining an agreeable solution to this perplexing problem.

We would like the following information from each member state of the AASCO where turfgrass seed is produced or offered for sale to establish labeling standards that are economically feasible and provide sufficient truthful information to the consumer. Your earnest help is solicited by the writer of this letter to provide the necessary background information requested below:

1. Recommended turfgrasses, mixtures, or blends for your area,

2. Crop seed generally found in turfgrass seed offered for sale in your area,

3. Number of crop seeds per pound that are found objectionable in turfgrass seed offered for sale in your area by rank as to objection,

4. Those objectionable crop seeds that you feel should be listed on the analysis tag to better inform the consumer as to quality of the mixture.

5. What crop plants or turfgrasses are in predominance in most of your turf areas three years after seeding,

6. Number of weed seeds per pound in turfgrass seed lots other than those required to be listed as secondary, restricted, or prohibited noxious weeds,

7. Should the present fine and coarse kinds of turfgrass seed labeling be retained? - Give reasons

If you feel further information should be submitted, please feel free to do so."

All members were asked to complete this questionnaire and send it to the Chairman by January 1, 1974. How do you rate success or failure when you request information on questionnaires? In our case, 42% or 21 of the 50 states answered. Sixteen of the 21 states felt that the fine textured and coarse kinds labeling should be changed.

Labeling

Seedsmen, turfgrass specialists, seed officials, and consumers are vitally interested in a workable turfgrass labeling that will give the proper information about a specific turfgrass seed lot. Uniformity in labeling is what we are striving to accomplish. Companies, like our host Scotts, can base their seed production, advertising, and sales planning on a long range basis without the hectic merry-go-round they are on now.

Companies spend thousands of dollars for research on a specific variety of grass only to have the Grass Committee declare it a coarse kind or to wait for two years for approval by the Lawn Grass Seed Subcommittee who may find something missing on the application or a time element not having been met and thus will have to wait another two years.

Turfgrass specialists have indicated that the consumer still does not get the information needed on turfgrasses with particular reference to noxious weed problems. Consequently turfgrass seed labeling is a very perplexing problem. What can we give the consumer which is within a realistic standard that the seed industry can furnish and meet. Having been a seed dealer, seed inspector, and farmer, this is how I see it:

1. Listing the turfgrasses that produce quality turf for the following uses:

   a. lawns
   b. golf courses
   c. playgrounds
   d. athletic fields
   e. roadsides
   f. erosion control

2. The general recommendations will have to be regional in nature because of latitude, altitude, temperature, and adaptability of a particular variety.

3. List crop seeds that are objectionable in turfgrass seed lots by a percentage or number by weight indication with realistic standards that seedsmen can meet. This listing would be similar to a restricted noxious weed list.

4. Each state would list their weed seed other than restricted noxious weeds that are objectionable.

If this is the situation, what kind of protection are we giving the consumer? Most State Seed Laws regulate the total amount of weed seed allowed in any seed offered for sale. A lesser amount may be the answer for turfgrass seed labeling.

I believe the basic problem of developing a labeling requirement should be worked out primarily by the state's turfgrass specialists. Suggested labeling could then be submitted to the AASCO for their consideration. Our Lawn Seed Subcommittee will still continue to work on the problem and maybe between both organizations, we can solve the problem.

In my travels throughout the United States, I think that about 15% of the homeowners manage their grass properly to have what I call a presentable lawn.

Labeling of turfgrass seed is not the whole solution. Education of the consumer is very important. Your extension turf specialists are doing a good job with the publications you have written but how extensively are these publications distributed and used. Many people do not know they are available and are free for the asking. Labeling seed and understanding the labeling is two different things. We must both work together to accomplish our goal of a quality, adaptable turfgrass seed offered for sale to the consumer.

Please feel free to contact the AASCO for any assistance or information on this subject because the problem needs to be solved as soon as possible.

Discussion Period

Dr. Daniel: You mentioned the possibility of getting rid of the category of coarse kinds. How near is this to being possible now?

Mr. Countryman: We are hoping that you gentlemen can help us come up with the proper labeling because it is going to have to be regional. In the southwest you have one turfgrass seed operation for summer grass and another for the winter. We do not have this problem in the northern areas, but we must have labeling that is as uniform as possible and yet, what protection are we supposed to give the consumer? We could go to idealism. But let us look at realistic situations. What are the economics for the seed producer? How good a seed can the consumer get and be willing to pay for it? This is the thing for which we are looking in labeling.

Dr. Keen: I wondered if Caucasian bluestem is considered a noxious weed anywhere.

Mr. Countryman: I did not see it listed.

Dr. Keen: This weed has spread into our area and it is really terrible.

Mr. Countryman: Well, that is one of the problems with our survey - not getting enough answers to our questions. I even had a director of an agriculture plant industry department say he was not qualified to answer. Yet he would not take it over to his turfgrass specialist and have him answer it. He sent the form back with three lines on it. That is supposed to suffice for a survey. We are trying to get some help. I get aggravated with my own organization. I am the one that sponsored this little survey and we are trying to get it done. That is one reason why Dick asked me here to enlist your aid and possibly to get this thing moving. It has been two years and we still do not have anything done.

Dr. Kaufmann: I have a lot of irate homeowners who cannot understand why after one season their lawn dies out completely. Is Italian and annual ryegrass snyonomous, and if so why is it not labeled annual ryegrass? Would this not be in the interest of the consumer?

Mr. Countryman: It is required to be listed as annual under the Federal Seed Act and our State Seed Laws, and it should be on the label. If the enforcement agent in your state has the law that covers that labeling, then it should be that way in your state. If the seed is moving interstate, it should have it on there by its predominance. If it is over 5% in the mixture, it has to be so labeled.

Dr. Hall: It seems to me that our present system of labeling is extremely deficient in that it provides no reward for the quality-minded seedsman. By that I mean to say, two lots of seeds can have 0.1% weed seed which can be bentgrass in one and a rather innocous weed seed in the other under the present system. We batted this around in our N.E. 57 regional meeting in Philadelphia in January and a suggestion made by Dr. Funk was that we support a label such as "Incompatible in this mixture." Let the research specialists on a regional level determine what they feel would be incompatible in this mixture. In other words, we would not want tall fescue in bluegrass whether it was .001% weed seed or other crop. I think we in N.E. 57 are in full support of any measure which would help us reduce other crop seed levels and list those seeds on a regional basis that are incompatible in the mixture.

Mr. Countryman: I think our big problem is putting turfgrass seed in a group by itself and have a section within the law that specifically lists turfgrass seed because in one area annual ryegrass does the job and in other areas you do not want annual ryegrass. But as you stated, this is the kind of labeling we need. However, we want it realistic although we feel that as turf people you would like to have the upper most quality with a 98% purity with maybe 2% inert. It is impossible when you are cleaning and handling seed. You just do not remove it all.

Dr. Newman: Ideally we would like to have seed that was literally free of any other monocot, and if not, so labeled. You have suggested that we give you some guidance. I think the seed trade also has a little responsibility here of letting us know exactly how much seed does have other crop in it, what the problem is, how difficult is it to produce seed without this (crop) in it, and some breakdown on the volume of this. Obviously, you cannot relegate all the bentgrass and tall fescue contaminate to highway seedings. There just is not that much potential there, but I think we have to know the other side of the picture in order to make an intelligent decision here.

Mr. Countryman: At the American Seed Trade Association we have another committee called Industry Control Relations where we sit down and try to "hash out" these problems. Your specific question will be on our agenda for the meeting which comes up the 30th of June. If you feel you need more information be sure to write me, and I will try to keep you informed.

Dr. White: I guess one of the things that has bothered me about this business ever since I have been involved in turf is the fact that we do not look at what the information means to the homeowner or the consumer. We do not look necessarily at his needs. I wonder if there has been any effort to have this translated back say with a survey to the homeowners instead of the turf specialists because many times we really do not see the problem. We see it after the homeowner has established it. After questioning homeowners about their incentive for buying seed of different types and their motivation and their understanding about what they bought I find that they are quite different than what I would interpret from the label. It would seem to me that it might be productive to tackle it from that point of view or at least along with the points of view of the experts and the people in the Seed Trade.

Mr. Countryman: We had a problem similar to what you described just in the last eight months. There was a promotion selling a combination grass product. It was depicted as an 11-year, all-season grass, i.e., green year-round. It happened to be a combination of crested dog-tail and colonial bent. It was selling for $7.50 a pound. People were buying it like it was going out of style. I talked before a number of garden clubs. I even took down the advertisements because it was false advertisement. It was called Mark IV. I told the newspapers to stop the advertisements but the grass is still being sold. People are going to be wiped out. All we require by law is truth in advertising and proper labels. There is no other way we can stop it from being sold other than informing the public that this is not doing the job. Somebody was telling the fellows in California just a little while ago that the crested dog-tail died when the water was off for about three days. The temperatures were from 105 to 116 degrees. The colonial bent will not take high temperatures or the alkali in the summertime and all the new homes with this new grass are suffering a $50 to $60 loss on each one of these sales.

Mr. Bangs: Back during the early years of the fine textured, coarse kind labeling Scotts struggled to find a set of words that would tell the consumer our seed quality story. One of the things was no crop seed in our seed mixtures. However, this does not mean anything to most consumers. So we were trying to find some words to tell the consumer that a seed lot does not have coarse grasses in it that may be objectional in their lawn. Well, we experienced difficulties trying to get words cleared through the various state regulatory agencies, but succeeded eventually. We have carried the statement on some of our packages now for several years that simply says this is guaranteed to be free of all coarse problem grasses.

Mr. Countryman: I think Dick has said some real good words here. You want to build on what we have worked on already. I think we still need statements that are truthful on the matter.

EXTENDING TURFGRASS INFORMATION TO URBAN CONSUMERS

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Nassau County, New York

Introduction

Nassau County was once a farming community producing potatoes and vegetables for the New York City market. Today, there are one and one-half million residents. They live in 400,000 dwelling units. Most of these are individual homes. Each home has approximately 4,000 square feet of lawn. There are 60 golf courses in the County. The parks and county owned property includes about 20,000 acres of maintained lawns. In addition, this area includes turf on the lawns of 200 schools plus the turfgrasses on roadsides, cemeteries, and commercial lawns.

The increasing population, more leisure time and tendency toward "country life" mean more interest in lawns. Since World War II, over one-half of the requests for information received by Agricultural Division of Cooperative Extension in the County have been on lawns.

There is a great diversity of experience relative to lawn maintenance by these homeowners. Many of them are just out of Metropolitan apartment buildings, while still others have had experience in maintaining one or more previous home lawns.

Nassau County Extension Personnel

At the present time, the Agricultural Division has six professional agents. One is a business management agent who works with the professional ornamental horticultural businesses. We also have one full-time horticultural consultant and one who works 60% of the time in this area. In addition, we have five secretaries - some of which are shared with the Home Economics Division. The Division budget has been running approximately $200,000 per year for the last few years with an actual decrease in staffing. About 95% of these funds come from the County.

In addition to the 7-Man Lay Executive committee which actually runs the Division, we have a 17-Man Turfgrass Advisory Committee which helps us plan our work and determine the most important problems in turfgrass. These 17 members represent garden centers, sod growers, landscape contractors, wholesale suppliers, turfgrass professors, custome applicators, lawn service agencies, golf course superintendents, landscape maintenance personnel, ag-chemical distributors, cemetery superintendents, seedsmen, shcool groundsmen and park horticulturists. Some of these people have been elected to this membership and represent a segment of the industry, while others have been selected by the agents. One of the Committee Members conducts the meetings which are usually held two or three times each year.

Professional Programs

Disease Conference - Last year we held a turf disease conference which was attended by over 300 Professionals. Turf disease specialists from several universities presented papers. This program was planned because the Turfgrass Advisory Committee indicated that turf diseases were the most important turf problem.

Turfgrass Survey - A questionnaire was used to survey the turfgrass problems. It was sent to 900 of our professional clients and we received 112 replies. Most of the replies mentioned that Fusarium Blight (*Fusarium roseum*) was the most important lawn problem, with "unidentified" diseases being second and leaf spot and dollar spot third in importance. Crabgrass (*Digitaria* spp.) and *Poa annua* were mentioned as the major turf weeds, with chinch bugs (*Blissus* spp.) and sodworms (*Crambis* spp.) the major turf insects.

Turfgrass Pathology - As a result of the survey and the turf disease conference, we were able to convince Cornell University scientists that more work was needed on lawn diseases. As a result, a turf pathologist was added to the staff at Cornell University and he is conducting turfgrass disease research on Long Island.

Educational Programs and Field Days - Every other year we hold a turf conference for Schoolground Superintendents with approximately 100 attending.

Each year, our agents assist the three primary landscape maintenance organizations in hosting a spring conference. The major emphasis is usually on turfgrass management and approximately 300 attend.

Three one-half day educational sessions were set up in the spring of 1974 for 100 Nassau parks grounds maintenance personnel. Presently, we are setting up a field day at Eisenhower Park for all publicly supported institutions in the metropolitan area for turfgrass equipment and supplies. Part of the field day will be held at our turf research and demonstration plots.

Each year, two agents assist the cemetery superintendent associations with a program for their field day and we are usually on their program for their winter grounds maintenance conference.

Our program with garden centers has been directed towards supplying participating garden centers with up-to-date information to make garden centers a respected local source of timely gardening information. Many of our garden center operators understand that disseminating information and selling products are complimentary as long as the problems are recognized and the appropriate material is sold. Our business management agent has helped many garden center operators to be better businessmen. Our weekly Garden Guides was originally set up to help garden center operators. Garden Guides has five short timely gardening messages which are sent out each week. They discuss solutions to the most prevalent problems. We find that many of the garden centers display Garden Guides each week and usually 'star' some items - most of the time on lawns.

We compile, alphabetize and index information leaflets and make them available in two handbooks. The "Lawn and Garden Handbook", was originally designed to help garden centers find pertinent information which was indexed and easy to use. These were sold to garden centers and landscape maintenance personnel for $10.00 a set. These have been revised with about 1,200 handbooks sold - 500 at the last printing. Many of these are now worn out, and we are getting requests to reprint these handouts.

In the past, we have usually set aside one day in August as a field day for professional turf personnel.

Telephone Services and Mailings - We have a special phone number only for commercial and professional calls because our other numbers are usually tied up with homeowner phone calls. In the summer of 1973 the agents manned a special 'early bird' telephone number for professional calls. Agents were at the phone at 7 A.M. This is being set up again for this summer. We have an annual fee of $5.00 for mailouts. At the present time, we have approximately 4,000 enrollees - about 900 of these are professionals.

Special Mailings - We have monthly mailings to professionals only. These contain new or helpful information of specific interest to those making their living in the field of horticulture.

Turfgrass Research and Demonstration Plots

At the present time, we have just over one acre of turf plots - all of which are turfgrass variety trials. These plots are a cooperative effort between Cornell University, the Agricultural Division of Cooperative Extension, and the Nassau County Park System.

In the past, Cornell University has been instrumental in designing what goes into the plots while the Agricultural Division has been helpful to overseeing the work at the plots and the Nassau County Parks System has been generous enough to supply much of the hand or machine labor to maintain the plots. This relationship has worked particularly well. Several similar trials were started in other areas of New York State but have had to be abandoned due to lack of interest. Dr. John Kaufmann, who replaced Dr. John Cornman last July, is now working with us on these plots. The plots have been in their present location for six years, but we have had a cooperative turfgrass effort for 20 years.

Programs For Homeowners

Presently we have 3,100 paid 'Enrollees' on the Agricultural Division mailing list who are homeowners. All of our enrollees receive a monthly Agricultural News, the weekly Garden Guides from mid-March to mid-November, as well as meeting notices and they may have their soil tested for pH.

Telephone Aids - During the last year, our Staff handled well over 28,000 phone calls concerning horticultural problems. As I mentioned before, about half of these are on lawns. Every hour of the day throughout the year, a call to 516/538-7585 will provide a 60-second timely gardening message. The message is changed each working day at noon. Over 47,000 calls were made to this number last year. A message on lawns is usually put on the recorded message device each Friday at noon. This message is left on until Monday noon.

Radio Programs - Six days a week between 10 A.M. and 11 A.M., we broadcast one-minute educational spots on horticultural topics over a local radio station. This radio station estimates they have a daily listening audience of over 300,000 people. Approximately one-third of the messages are on lawns.

Television - Recently we have been invited to appear on a local television station with a half-hour gardening program. During this program, homeowners call in their gardening problems to five telephone operators who write down the questions on cards. They are then given to the agents for answers. Of course, many of the questions are on lawns.

Newspapers - Nearly all of the normal activities mentioned above reach a small segment of our population. The one mass media that does cover the major part of the population is newspapers. We have excellent coverage with two Long Island newspapers and the New York Times. The two local papers give us weekly coverage almost all year long. Whenever we feel a problem is of significance, we can usually get extra coverage. For instance, a special article on "Fusarium blight of lawns" with professional photographs should be appearing about now in Newsday.

Adult Education - In order to reach a broader audience and to make more effective and efficient use of our agent's time, we offer a program on horticultural topics in cooperation with the Adult Education Programs of the 54 school districts. Similar programs are presented to the 53 libraries via the Nassau County Library System. Fifty-six such programs were conducted last fall and we just finished a like amount this spring. Usually three topics are offered each season. Up until this spring, the most popular topic had been lawn care. This spring, however, vegetable topics were more popular than talks on lawns.

Horticultural Clinics - During the last year, we conducted six Saturday morning horticultural clinics at Eisenhower Park. One of these was in connection with our regular "Turfgrass Field Day". Over 900 individuals attended the six sessions. Hundreds of them brought samples of plant problems to be identified.

Garden Calendar - A professionally printed informative week-by-week guide, the "Long Island Gardening Calendar", was produced by the Agricultural Division for the metropolitan area. The information in this guide emphasizes the prevention of horticultural problems as well as remedies. To date, 22,000 copies of this guide have been printed and sold at 50¢ per copy.

Exhibits - Each year at several of the Flower Shows, we have an exhibit or display. Frequently these exhibits are on lawns or lawn problems. During March, we usually man a "question and answer" booth at the Long Island Garden Show.

Office Visitors - Visitors to our office with dead turfgrass samples are a common sight. Although we have not counted these during the last several years, the number is probably over 2,000.

Horticultural Index - The heart of answering homeowner problems lies in a Rolodex System. When the visitor's problem is identified, we refer to the Rolodex System for hand-out literature whether it is a bulletin or a leaflet. This information is then given to the homeowner to answer the specific problem. We have 314 leaflets which were written by agents to hand the individual a single sheet or several sheets of literature, rather than an entire bulletin, which may cost 20¢ or more. Forty of these leaflets are on lawns. In addition to the leaflets, we have the normal Cornell University bulletins as well as several other bulletins from nearby universities which we feel are appropriate and not covered by Cornell publications. Well over 3,000 letters are also answered each year. Many of them with leaflets, bulletins, or an individual letter from an agent.

Summary

Almost everything we do increases the public's knowledge about our organization, and this creates more demands upon our staff. We get a few irate people who are unable to reach us by phone; but we do get many more who really appreciate our work. We are constantly looking for ways to improve our system. It's like having a "tiger by the tail" and not knowing what to do with it. We hope help arrives soon with some "computerized information device" or something similar. Any ideas would be appreciated.

Discussion Period

Mr. Jenson: Have you attempted any clinics in large malls or shopping centers as a way of expanding your services to various segments of the county?

Mr. O'Knefski: The one thing that we have done is to publicize that on certain days of the week we will be located in one of the four 4-H centers located throughout the county. We have talked about going into the large malls but we have never geared up for it. We talked about having our "Plant Clinic" van setting in the mall on a Saturday but we presently feel that we don't need any more personal contact with people. As I mentioned before, everything we do increases our volume of business. How do we overcome it?

Dr. Duble: Bob, you kept mentioning that support for your program has declined, yet it looks like the demand for your services keeps increasing. Why is that?

Mr. O'Knefski: What it amounts to is that we have not had very good public relations with the County Board of Supervisors. They furnish the money but do not know what is actually happening in the program. We have seven men on the County Board of Supervisors and one man that's supposed to be representing Extension, but he doesn't attend any of our meetings.

Dr. Keen: Do you have some plan whereby you can divert many of these questions to the commercial people, i.e., the garden centers, the other landscape maintenance professionals or others so that they do not all come to you?

Mr. O'Knefski: Well, we think we have done a good job of educating the garden center operators and in many of the newspaper articles we tell people to visit their local garden centers. But, many times the local garden centers operator receives questions he can't answer so he refers these people to us. It doesn't quite work out the way it should. We just have not had enough of this type of activity. We have even though of inviting garden center operators or landscapers in to help us answer our phones on a voluntary basis.

Dr. Keen: You haven't tried to answer the phones on a TV station?

Mr. O'Knefski: Yes, we do have a local TV program, a half hour every other week, where people can call in their questions. We usually have five telephone operators that receive the calls and write the question(s) on cards and the two agents particpating answer the questions. Clark Jenson has several good programs. One was a tape device he might want to say a word about. Clark, would you want to say something about your telephone taping device?

Mr. Jenson: Yes, the tapes we have are an index system, where the tapes are located in front of the secretary and when someone calls on a specific item she can withdraw that particular tape and put it in the phone but it is time consuming and takes more labor. I think we are probably going to a telephone system as you have, where it's a teletape approach.

Dr. Mazur: In South Carolina, we have had some complaints from the homeowners that they are not able to obtain the recommended materials, such as pesticides. How do you handle problems like that at the county level?

Mr. O'Knefski: The new agent on the staff will be working with garden centers; one of her tasks right now is to visit garden centers with a list of our recommended materials to find out who has these materials so that when we do get requests we will be able to recommend areas where the materials can be purchased. We would have a problem recommending an individual garden center, so we would need to list several of them. This is also one of our ways of telling garden centers what we are recommending.

Mr. Countryman: Yes, Bob, we have found that by having a garden clinic or something set up in these large urban shopping centers we get better exposure and it also tells our story. We also found that if we document a story and give it to the supervisors of our county agents or even our state operations to the legislatures they get to know it and can't always depend on them coming to your meetings or whatever is involved. But we send out our brochure, to the county that's showing your document of what you are doing. The number of man hours that you are spending on request calls. You would be surprised at the response that you get. We, in Arizona, have all these inspection stations where we meet many people every day.

IDENTIFICATION, CAUSE AND EFFECT AND CONTROL OF THATCH IN BERMUDAGRASS TURF

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Thatch origninates from undecomposed organic residues that accumulate on the soil surface under intensified turf management. Vigorous grass selections, excessive fertilization, frequent watering and extensive use of plant protectants all may add to the problem of organic residue accumulation in turf. Two terms - mat and thatch - have been used to describe this layer of organic residue. Mat may be defined as the mass of roots and stems beneath the green vegetation and is associated with sponginess in turf (Ferguson, 1964). Thatch may be defined as an accumulation at the soil surface of dead but undecomposed stems and leaves. Both mat and thatch may occur singly or together. For purposes of this discussion, thatch is defined as the accumulation of living and dead undecomposed root, stem and leaf tissue between the soil surface and the green vegetative cover. Thus, it includes both the mat and thatch previously described.

In bermudagrass turf thatch consists of a layer of stems and roots entwined in partially decayed leaf, stem and root tissue between the soil and the green leaves. This thatch layer is characterized as being fibrous in nature and highly resistant to microbial breakdown. As the thatch continues to accumulate, decomposition is further retarded by the increase in lignin content which renders much of the thatch layer inaccessible to microbial breakdown. Physical examination of the thatch layer indicates that it consists primarily of stem, node and sheath tissue in various stages of decay (Ledeboer and Skogley, 1967). Grass clippings which consist largely of leaf blade tissue do not significantly contribute to the thatch layer (Lebeboer and Skogley, 1967 and Meinhold, et al, 1973).

Thatch accumulation is a direct result of management practices that produce abundant vegetative growth (Meinhold, et al, 1973). High rates of nitrogen fertilization, infrequent mowing and frequent irrigation are factors that contribute to thatch accumulation (Madison, 1962). Many improved turfgrass cultivars such as Penncross bentgrass and Tifdwarf bermudagrass have a vigorous shoot growth rate that encourages thatch accumulation. The failure to maintain a balance between growth rate and decomposition ultimately results in the accumulation of thatch.

Thatch decomposition is a function of grass variety, soil microenvironment and management. For example, Penncross bentgrass and Tifdwarf bermudagrass have a greater tendency to develop thatch than Seaside bentgrass or common bermudagrass, respectively. Likewise, environmental factors that favor dense populations of microorganisms encourage the decomposition of thatch. Aerification, vertical mowing and topdressing illustrate management tools that help in the decomposition of thatch (Ward, 1969). When decomposition and growth rate are out of balance, thatch begins to accumulate.

Excessive thatch accumulation results in a number of maintenance problems and in poor quality turf. Thatch creates problems with mowing, watering and fertilizing; provides a favorable environment for insects and disease organisms; increases winterkill; and impairs the trueness of playing surfaces. On the other hand, a limited amount of thatch may reduce or alleviate soil compaction, protect the crowns and nodes against climatic or mechanical injury, conserve moisture, minimize erosion, lessen player injury by imparting resilience to playing surface, reduce weed growth and filter harmful pollutants and residues.

Materials and Methods

Identification

Thatch samples were collected from bermudagrass turf throughout Texas to characterize its chemical makeup. Undisturbed sod plugs including at least one inch of soil were collected from golf greens, tees, fairways, parks and lawns from South Texas, the Gulf Coast, Central Texas, North Texas and the Texas Panhandle. Varieties were identified and previous maintenance history was recorded. The green vegetative growth was removed by clipping the plugs with scissors to represent a moderate scalping with a mower. The sod plugs were then separated individually into soil and organic fractions by cutting cross-sections of the plug with a knife until the organic fraction was essentially removed. The soil present in the organic fraction was separated by ashing following chemical analyses of the organic fraction. Thus, the results of the chemical analyses of the thatch are expressed as a percentage or organic matter. Thatch was defined as the organic matter between the soil and the green vegetative cover. Thus, thatch included both living and dead organic tissue which as predominantly stem tissue as shown by Ledeboer and Skogley (1967).

The thatch was oven-dried at 70°C and ground to pass a 40-mesh screen. Chemical analyses for cellulose and lignin were conducted according to the procedure of van Soest and Wine (1967). Organic matter was determined by subtracting residual ash from the original sample weight.

A similar investigation was conducted on 150 bermudagrass selections grown under uniform management. Clippings from the 150 bermudagrass were analyzed for cellulose and lignin content. From these 150 grasses, 15 were selected to be planted on a 6,000 square foot putting green built specifically for this project. The 15 grasses were characterized by a relatively wide range in cellulose and lignin contents. The objective was to relate thatch accumulation to either cellulose and lignin content of the grass or a ratio of lignin to cellulose. The putting green was maintained as a normal golf green, but no effort was made to mechanically eliminate thatch. The grass clippings were periodically sampled and analyzed for cellulose and lignin. At the end of each growing season, the plots were sampled for thatch accumulation as previously described.

Cause and Effect

An established Tifgreen bermudagrass putting green was used in 1972 to study the relationship of fungicides, clipping residue, and fertility to thatch accumulation. A split plot design with three replications was employed.

The main plots consisted of the following: 1) fungicide treatment - 6 oz/1000 ft^2 of Manganese ethylene bisdithiocarbanate (Fore) or 4 oz/1000 ft^2 of Tetramethylthiuram disulfide (Tersan OM) applied alternately at 2 week intervals, 2) clipping residue - mower clippings not collected, and 3) control - clippings collected and no fungicide.

Sub-plots consisted of fertilizer treatments randomized within each main plot. Two sources of N, ammonium sulfate and activated sewage sludge (Milorganite), were applied at two levels, 0.5 and 1.5 lbs/1000 ft^2, every two weeks. Muriate of potash treatments consisted of 0 and 1.5 lbs/1000 ft^2 applied every 4 weeks. A blanket application of P was made at the rate of 3 lbs/1000 ft^2 over the entire area at the beginning and halfway through the study.

No cultural practices other than those mentioned above were applied during the experimental period, May 15 to October 23. The green was vertically mowed and aerified 1 week before the first fertilizer treatments were applied on May 15.

Total thatch accumulation was measured at the beginning and end of the study by taking eight plugs at random from each sub-plot and measuring the thatch layer with a ruler. Each plot was sampled three times during the experimental period by taking three 2-in plugs at random. The plugs were washed and screened to remove soil. The samples were dried at 70°C, weighed, and ground in a Wiley Mill with a 40-mesh screen. The analytical procedures were those as outlined by van Soest and Wine (1967) to determine cellulose, lignin, and ash.

At the end of the 1972 study, visual ratings were made of the plots to estimate the effect of treatments on scalping after mowing and on color. A rating scale of 1-10 was used with 10 being the most severely scalped and the darkest green. The ratings were subjected to analysis of variance to determine the effects of treatments on scalping and color.

The same putting green was used in 1973 to study the effects of several fungicides and a growth retardant on thatch accumulation. Again, the fungicides - Fore at 6 oz/1000 ft^2 and Tersan SP at 4 oz/1000 ft^2 at 2-week intervals - and a growth retardant - Sustar at 1.5 oz/1000 ft^2 - and an untreated check constituted the main plots and nitrogen rates - 1, 2 and 3 lbs/1000 ft^2/mo - and sources - Milorganite, ammonium sulfate and ammonium nitrate - comprised the sub-plots. Thatch accumulation was measured 3 months after the initial treatments were made.

Control

Cultural practices including vertical mowing, aerification and topdressing were studied in relation to thatch accumulation. A Tifdwarf bermudagrass putting green at College Station, mowed 3 days per week at 1/4 inch, was used as the experimental site. Three frequencies of vertical mowing - none, biweekly and monthly - each three frequencies of aerification - none, biweekly and monthly - each at two levels of N - 1 and 3 lbs N/1000 ft^2/mo. - were studied in a factorial design. Aerification and topdressing were confounded since the aerifier cores were shredded and dragged in place to serve as topdressing. Thus, the plots that were not aerified did not receive topdressing. Thatch accumulation was measured in these plots 3 months after cultural treatments were initiated.

Biological thatch control through the addition of soil activators at recommended rates was also investigated at several rates of nitrogen on the Tifdwarf bermudagrass putting green.

Results and Discussion

Identification

The bermudagrass samples collected to characterize thatch were representative of a number of environmental conditions, management practices and bermudagrass varieties. The only uniformity existed in the sampling, handling and analysis of the samples. The majority of the samples taken from golf greens and aprons surrounding the greens. In general, the sampling was biased toward intensively managed turf. The samples represented 10 locations in Texas and 5 varieties of bermudagrass including common, Tifgreen, Tifway, Tifdwarf, and Gene Tift. The thickness of the thatch layer ranged from 0.2 in. to 1.8 in. with an average of 0.7 in. The chemical composition of the thatch in terms of cellulose and lignin is shown in Figures 1 and 2. The lignin content of bermudagrass thatch ranged from 10 to 34% with a mean of 23.2%. In contrast, bermudagrass clippings averaged only 4.1% lignin. As might have been predicted, lignin accumulated in the thatch layer. This can be attributed to its resistance to microbial decomposition as documented in the literature. Certainly, if the thatch had been separated into layers, the lignin content would increase in the layers nearest the soil. There was little relationship between the thickness of the thatch layer and the lignin content. But, generally the higher lignin contents were associated with the thickest thatch layers (Table 1).

The cellulose content of the thatch ranged from 4 to 19% with a mean of 11.0%; whereas, bermudagrass clippings had a mean cellulose content of 23.3%. Thus, cellulose was readily decomposed by soil microbes. The lignin to cellulose ratio changed from 0.2 in the plant tissue to 2.1 in the thatch. If the lignin to cellulose ratio is an important factor in organic matter decomposition in soils, as has been demonstrated in forage digestibility by rumen microbes (van Soest and Wine, 1967), then accumulation of lignin in thatch is a limiting factor in decomposition by microbes.

Differences between bermudagrass varieties and locations were not apparent from the data. The effects of environments in terms of fertility, moisture, soils and temperatures were overcome to some extent by management practices. Also, management practices were too different between locations to establish differences between grass varieties. However, the relationship between lignin and cellulose was the same for all locations and all varieties.

The chemical composition of some of the 150 bermudagrass selections/introductions are shown in Table 2. Lignin content ranged from 3.0 to 5.3% in grass clippings with a mean of 4.1%. In 3 of 5 species studied, the lignin content varied considerably within species. Only one strain of Cynodon hirsutus was obtained and the three strains of Cynodon barberi demonstrated very consistent lignin contents. C. datylon, C. magennissii and C. transvaalensis showed similar mean lignin contents and similar variation between strains.

The cellulose content of the grasses differed more than their lignin contents. In general, C. transvaalensis strains were significantly lower in cellulose than the other species. More important, perhaps, is the effect of cellulose on the lignin to cellulose ratio between the different strains. Disregarding the U.S.A. selections of C. dactylon, the lignin to cellulose ratio is significantly higher in C. transvaalensis strains than in C. dactylon strains. This may be an important factor to consider in a breeding program and may, in part, explain the tendency of C. dactylon x C. transvaalensis crosses to accumulate thatch as exemplified by the "Tifton series" of bermudagrass.

In 15 bermudagrass varieties maintained under putting green conditions thatch accumulation ranged from less than 0.1 in. to more than 0.5 in. in a single growing season. Tifgreen and Tifdwarf bermudagrass averaged 0.6 and 0.5 in., respectively. A selection of C. transvaalensis (PI 286584) had a total of only 0.1 in. of thatch after one season's growth. Samples were taken at monthly intervals from each plot, measured for thatch accumulation and analyzed for lignin and cellulose. Figure 3 demonstrates the rapid accumulation of lignin in a bermudagrass turf. Also, a close association is shown between lignin and thatch accumulation. The opposite relationship was found between thatch accumulation and cellulose (Figure 4). As the season progressed the percent cellulose in the thatch decreased from 22.5 to 15.5. This decrease demonstrates the decomposition of cellulose by microbes and the change in composition of the turf from leaves to stems as the season progressed. All chemical analyses were made on the entire turf (grass and thatch plugs) taken from each variety. We did not attempt to separate the grass and thatch in this study. Certainly, if we had only analyzed the thatch, the lignin content would have been higher and the cellulose lower.

The relationship between thatch accumulation and the lignin/cellulose ratio is shown in Figure 5. The ratio changes from that of the grass in May to that of a mature turf in September.

The relationship shown in Figure 5 is discontinuous since the thatch is largely removed by mechanical operations each fall prior to overseeding. However, the lignin/cellulose ratio will be progressively higher at the beginning of each year. The significance of the lignin/cellulose ratio to microbial decomposition is shown in Figure 6. Leaf tissue which had a very low L/C ratio was readily decomposed by soil microbes; whereas, roots which had a high L/C ratio were decomposed much more slowly. Thatch was decomposed at variable rates depending on the L/C ratio of the thatch which increased with time. The relationship shown in Figure 6 suggests that the rate of thatch decomposition decreases with time because the L/C ratio of the substrate increases as the decomposition proceeds.

Cause and Effect

Thatch accumulation in a Tifgreen bermudagrass turf was increased by a high rate of N compared to a low rate of N over a 6-month growing period (Table 3). Nitrogen source also influenced the rate of thatch accumulation (Table 3). At each rate of N, plots fertilized with Milorganite accumulated less thatch than those fertilized with $(NH_4)_2SO_2$. Direct measurements on plant growth were not taken, but an indication of relative plant growth was available from observations on color and severity of scalping after mowing (Table 4). The $(NH_4)_2SO_2$ treatments were darker green and scalped more severely than the Milorganite treatments. Starkey (1953) has reported that one of the principle reasons bentgrass develops a thatch is that it produces extensive top growth. The same concept holds true for the N stimulated growth of bermudagrass in this study. Potassium treatments had no measurable effect on thatch accumulation.

Thatch accumulation might be expressed as a function of growth rate and the rate of decomposition of plant residues. The rate of decomposition of organic residues has been shown to be influenced by their chemical composition (Duble and Weaver, 1973). The lignin content of the thatch for the three sampling dates was influenced by N sources and rates (Table 5). The lignin content increased in all N treatments from August to October. By the October sampling date, lignin increased significantly with increased N within each source. In general, increases in lignin, which is highly resistant to decomposition, corresponded to increases in thatch accumulation.

Although clipping residues did not influence the weight of the thatch layer, they significantly affected plant growth and thatch accumulation (Table 6). Scalping did not occur on any of the plots receiving the fungicide applications, but was pronounced where clippings were not collected (Table 4). The fungicide treated plots were not as dark green in color as the other plots, but satisfactory turf was maintained (Table 4).

Potassium treatments did not influence any of the parameters measured in this study. The level of K in the soil prior to initiation of treatments was determined to be 224 lbs/acres. Although this was not a large amount of K, it could have been sufficient to mask any effect that K treatments might have had on these parameters. Since this investigation covered only a single growing season, the possibility of K affecting thatch accumulation over a period of years could not be eliminated.

These results suggest that a slow-release form of N applied at a level to maintain acceptable aesthetic quality and to avoid excessive plant growth may reduce the problem of thatch. Also, since clipping residue did not greatly increase thatch, allowing the grass clippings to fall to the surface may be a feasible management practice. This practice would allow a recycling of plant nutrients and eliminate the clipping disposal problem. Further research needs to be done with fungicides or plant growth regulators to determine their usefulness in controlling thatch.

The 1973 results confirmed earlier conclusions that nitrogen rates and sources influence the rate of thatch accumulation. Measurements made on the Tifgreen bermudagrass putting green showed an increase in thatch with each increase in nitrogen rate regardless of the nitrogen source (Table 7).

Also, the investigation demonstrated that organic and slow-release nitrogen sources produce less thatch than inorganic nitrogen sources such as ammonium sulfate (Table 7). However, the lowest rate of nitrogen studied per application was 1 pound per 1000 square feet. If smaller and more frequent applications of inorganic fertilizer were made, then the difference in sources may not be as apparent. Two years of intensive research and many years of observation suggests that turf should be kept "hungry" for nitrogen to maintain a balance between thatch accumulation and decomposition.

The effect of several fungicides and a growth retardant on thatch accumulation in bermudagrass turf was also studied. Applications of each of the materials shown in Table 8 were made to the turf at 2-week intervals. The effects of these materials on thatch accumulation were striking and readily explained by their influence on plant growth and microbial activity. The growth regulator and the fungicide combination (Fore and Thiram OM) apparently retarded the growth of the bermudagrass and thereby reduced thatch accumulation. The fungicide, Fore, applied alone at 2-week intervals at preventative rates resulted in a significant increase in thatch accumulation which might be explained by an inhibition of microbial activity that reduced the rate of thatch decomposition. Tersan SP which is a fungicide specific for Pythium resulted in greater thatch accumulation than the check, but much less than when Fore was used. Apparently Tersan SP had little effect on the microbes important in thatch decomposition.

These results suggest that preventative fungicide programs may have a significant effect on thatch accumulation in bermudagrass turf. Fertilization programs may need to be adjusted to reduce thatch when preventative fungicide programs are essential. Information obtained from the three nitrogen rates used indicate that where a fungicide is used routinely, lower nitrogen rates should be used to prevent excess thatch accumulation.

Control

Cultural practices including vertical mowing, aerification and topdressing have been recognized as methods of controlling thatch in bermudagrass turf. The effect of the frequency of vertical mowing and aerifying on thatch accumulation was studied on bermudagrass turf at two rates of nitrogen (Figures 7, 8 and 9). Monthly aerification was shown to be as effective as biweekly aerification as far as thatch accumulation was concerned (Figure 7). Biweekly aerification also resulted in lower turf quality ratings and would have been unacceptable in terms of putting performance. Perhaps aerification at less frequent intervals would have been satisfactory, but this was not determined. Vertical mowing alone and in combination with aerification reduced thatch accumulation significantly (Figures 8 and 9). Biweekly vertical mowing produced superior turf and reduced thatch accumulation significantly compared to less frequent vertical mowings. Apparently, weekly vertical mowing would reduce thatch and improve putting quality even more than biweekly operations. As shown in the fertilization study, high nitrogen rates resulted in greater thatch accumulation regardless of the frequency of aerification and vertical mowing.

Biological thatch control through the use of soil activators was not effective under the conditions of this investigation. Microbial activity and thatch decomposition were not affected by a single application of soil activators at recommended rates of application. Soil activators used in this investigation included Medina, Supernate, Energizer, Turfzyme, Super-Bio, Bio Act and Soil Life.

The information gained in this investigation indicates that thatch accumulation is influenced by all of our management practices as well as by the grass variety. Thatch control must be a result of a complete management program, and not just the result of a single operation. Organic and slow-release nitrogen sources should be used and excessive rates should be avoided. Fungicides should be used only as needed to control diseases. Routine applications of broad spectrum fungicides encourage the accumulation of thatch. Cultural operations should be employed on a regular schedule depending on the grass variety and soil type. Aeration and topdressing 3 to 4 times per year greatly improves turf quality and reduces thatch.

Biweekly verticutting also helps control thatch accumulation in bermudagrass turf. Although irrigation and mowing practices were not included in this investigation, other workers have suggested that infrequent irrigation (as the grass shows the need instead of on a daily basis) and close frequent mowing helps to control thatch accumulation.

Acknowledgement

The financial support from the O. J. Noer Research Foundation, Inc. for this research project is greatly appreciated.

Literature Cited

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LIST OF TABLES

Table 1. Lignin and cellulose content of thatch samples collected from bermudagrass golf courses throughout Texas.

Location	Variety	Thatch (inches)	Lignin (%)	Cellulose (%)
San Antonio	Common-1	0.4	10	4
	Tifgreen	0.2	17	8
	Tifway	0.6	26	9
	Common-2	1.6	32	10
Houston	Tifway-1	0.4	22	15
	Gene Tift-1	0.5	30	9
	Gene Tift-2	0.8	31	9
	Gene Tift-3	1.0	30	10
	Tifway-2	0.8	25	19
	Tifgreen	1.0	34	9
Austin	Tifdwarf-1	0.9	19	11
	Tifdwarf-2	1.2	22	12
Dallas	Common-1	0.4	26	15
	Common-2	0.8	24	10
	Common-3	1.8	31	11
Tyler	Gene Tift	1.0	21	12
Temple	Tifgreen	0.6	23	9
Greenville	Common	0.6	13	7
Pittsburg	Tifgreen	0.4	20	12
Overton	Common	0.4	20	13

Table 2. Lignin to cellulose ratios of grass clippings from 150 bermudagrass selections grown under similar management, College Station, Texas.

Species	Lignin/Cellulose Ratio Average	Range
Cynodon barberi 3 selections	.14	.13 --- .15
Cynodon dactylon 13 selections	.17	.13 --- .25
Cynodon hirsutus 1 selection	.13	.13
Cynodon magennissii 9 selections	.15	.15 --- .21
Cynodon transvaalensis 26 selections	.21	.15 --- .25
Cynodon spp. 100 selections	.17	.11 --- .25

Table 3. Effect of fertilizer treatments on the depth and weight of a thatch layer in a bermudagrass putting green after 6 months of growth.*

N Source	lbs./1000 ft.^{2}/mo.	Depth in	Weight g
Milorganite	0.5	.28 a+	3.2 a
$(NH_4)_2SO_4$	0.5	.32 b	4.0 bc
Milorganite	1.5	.40 c	4.3 cd
$(NH_4)_2SO_4$	1.5	.44 d	4.6 d

* Depth of thatch at the beginning of the study was .08 in for all plots. The mowing height (.25 in.) was subtracted from all thatch measurements.

+ Values within a column followed by the same letter are not significantly different at the .05 level by Duncan's test.

Table 4. Effect of fungicides and clipping residue on the color and severity of scalping of a bermudagrass putting green.

Treatments	Ratings* Color	Scalping
Fungicides	4.5 a	1.2 a
Control	5.4 b	2.4 b
Clippings	8.7 c	6.3 c

* For color 1 = yellow; 10 = dark green
For scalping 1 = no scalping; 10 = severe scalping

+ Values within a column followed by the same letter are not significantly different at the .05 level by Duncan's test.

Table 5. Percent lignin of above soil plant material as affected by nitrogen rate and source.

N Source	lbs N/1000 ft^2/mo	% Lignin Aug 1	Sept. 1	Oct. 1
Milorganite	0.5	6.9 a*	7.3 ab	8.1 a
$(NH_4)_2SO_4$	0.5	7.4 abc	8.3 b	8.7 ab
Milorganite	1.5	7.2 ab	8.1 b	9.1 b
$(NH_4)_2SO_4$	1.5	8.3 bc	9.3 c	10.3 c

* Values within a column followed by the same letter are not significantly different at the .05 level by Duncan's test.

Table 6. Weight and depth of thatch on October 1 as affected by fungicides and clipping residue.*

Treatments	Depth (in)	Weight (g)
Fungicides	.33 a+	3.87 a
Control	.36 b	3.99 a
Clippings	.39 c	4.16 a

* Thickness of thatch at the beginning of the study was .08 in for all plots. The mowing height (.25 in.) was subtracted from all thatch measurements.

\+ Values within a column followed by the same letter are not significantly different at the .05 level by Duncan's test.

Table 7. Thatch accumulation in a Tifgreen bermudagrass putting green as affected by nitrogen sources and rates.

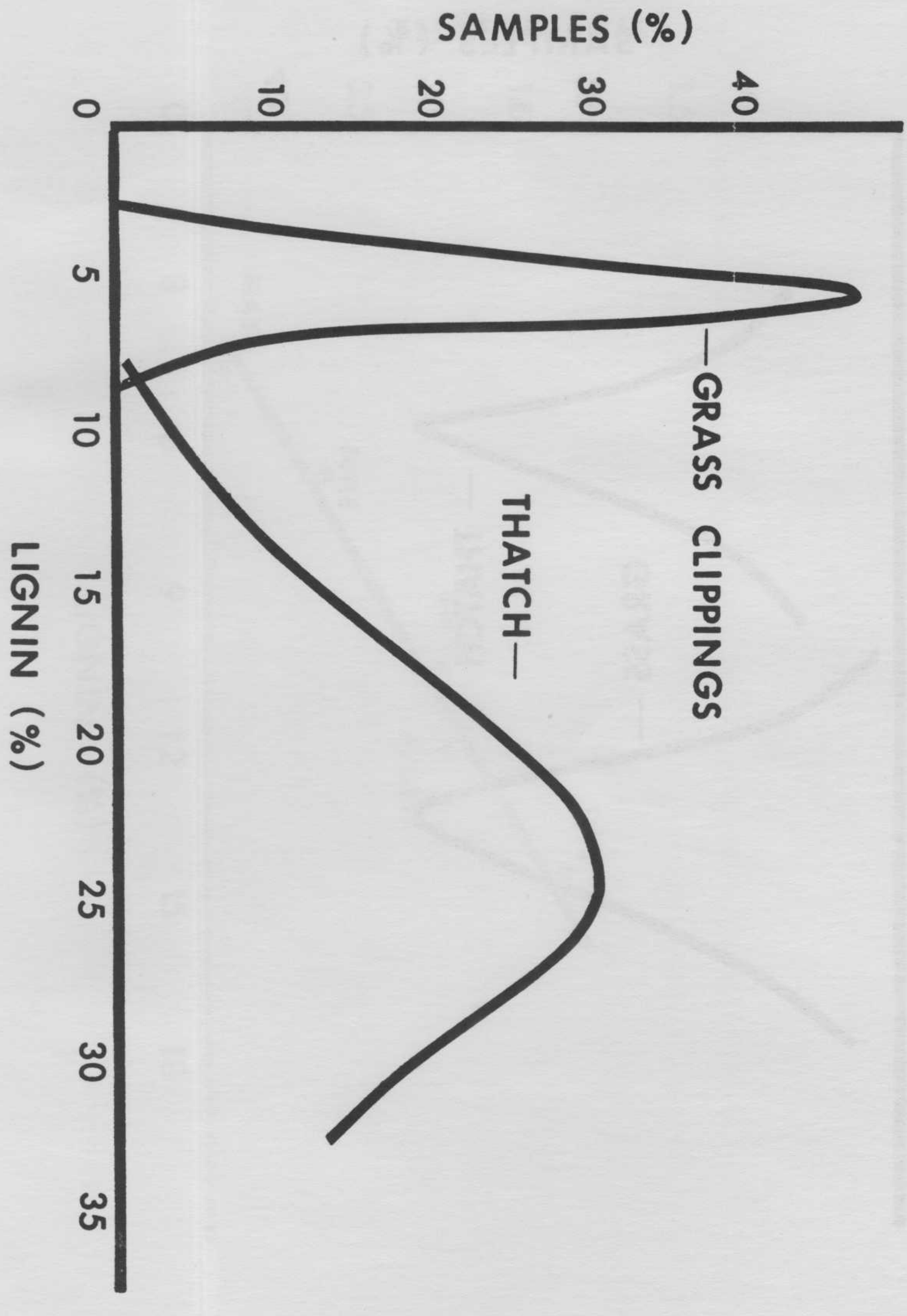
N Source	Rate[1]	Thatch (in)
Milorganite	4	.24
	6	.25
	12	.29
Ureaform	4	.20
	6	.26
	12	.29
Ammonium sulfate	4	.26
	6	.28
	12	.31

[1] Pounds N/1000 ft^2/12 week period

Table 8. Thatch accumulation in a Tifgreen bermudagrass putting green as affected by fungicides and a growth retardant applied at 2-week intervals.

Fungicide or Growth Retardant	Thatch (in.)
Fore	.32
Tersan SP	.28
Check	.25
Thiram OM-Fore	.23
Sustar	.19

LIST OF FIGURES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30
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GRASS CLIPPINGS
THATCH
LIGNIN (%)
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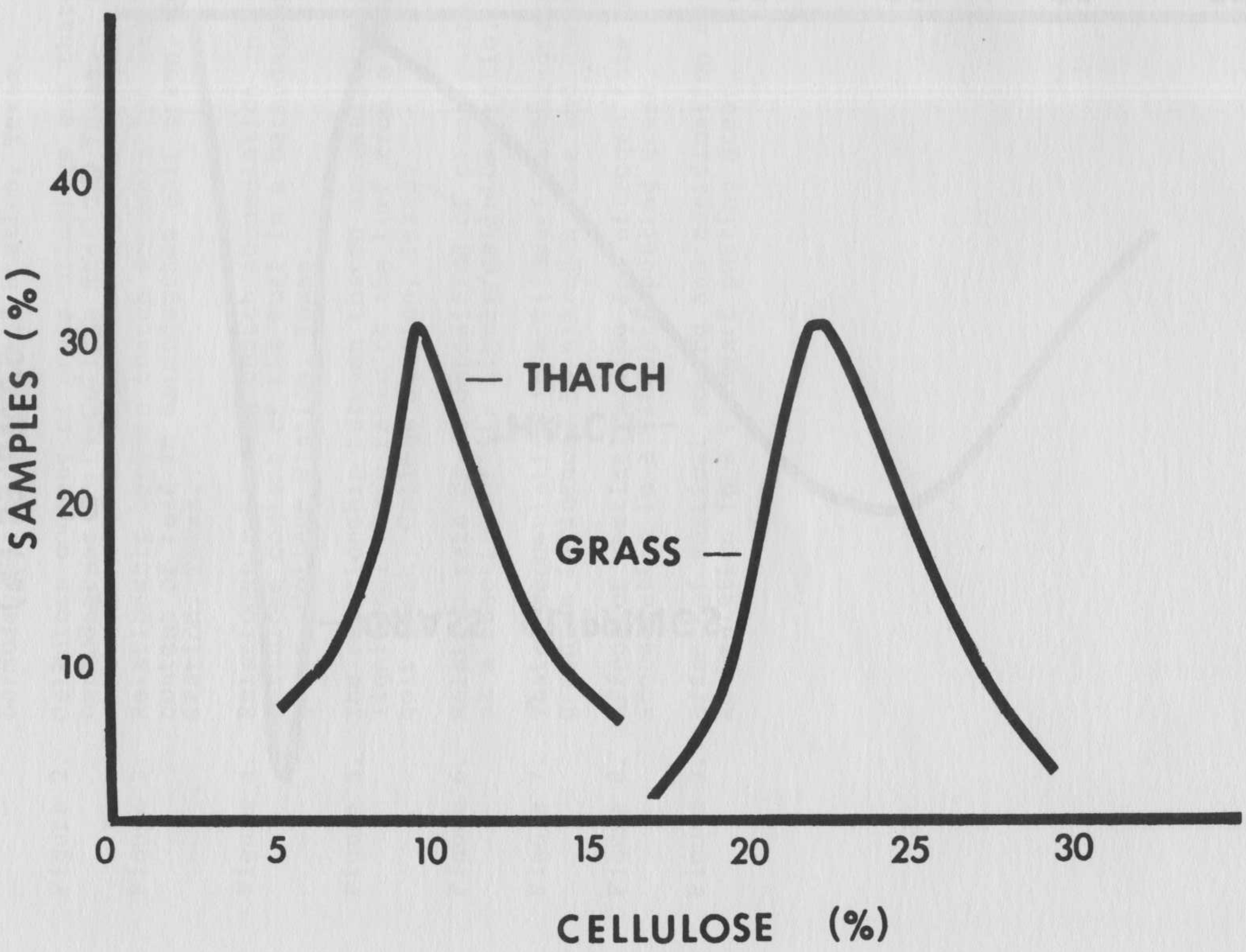
10
15
20
25
30
35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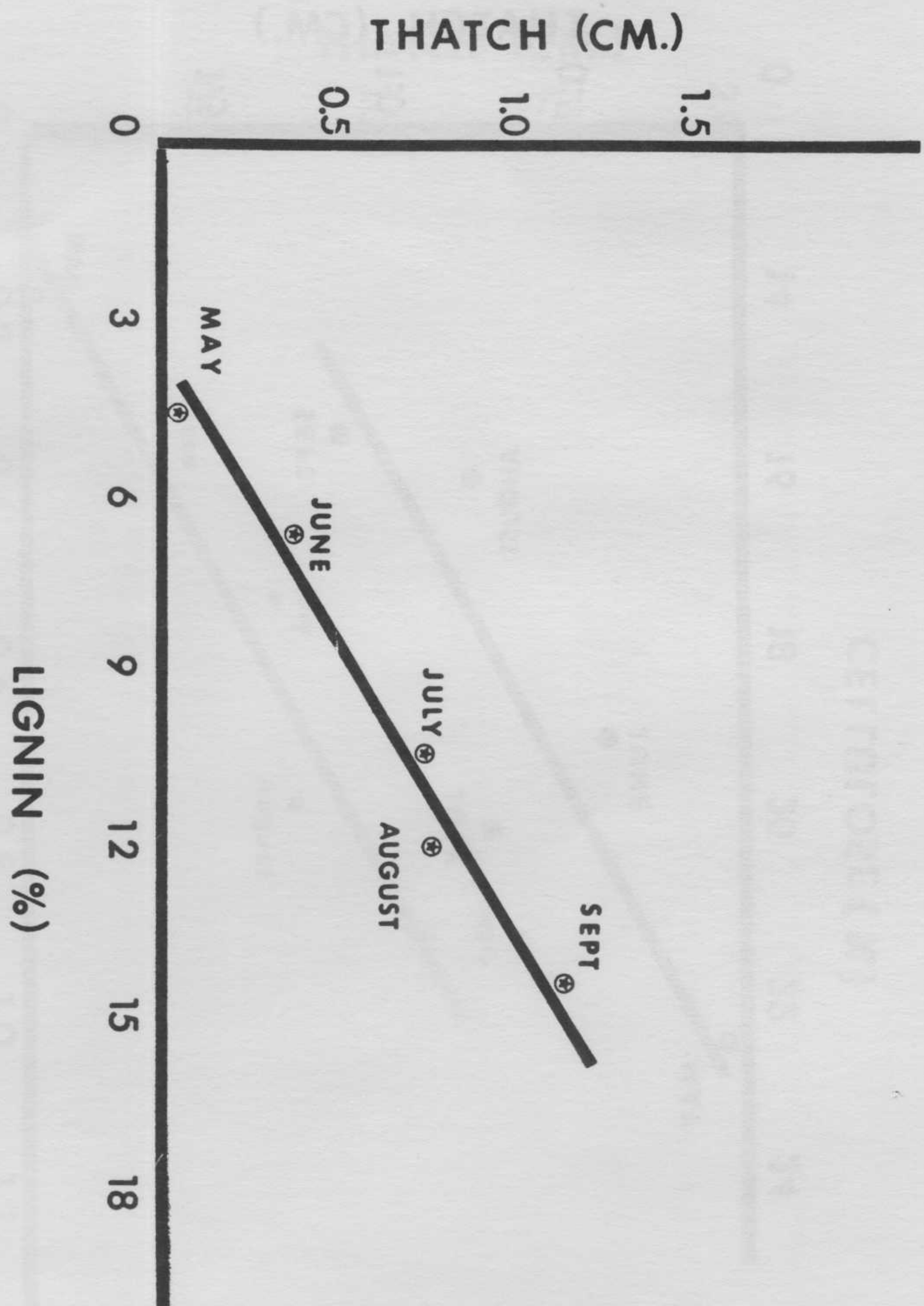
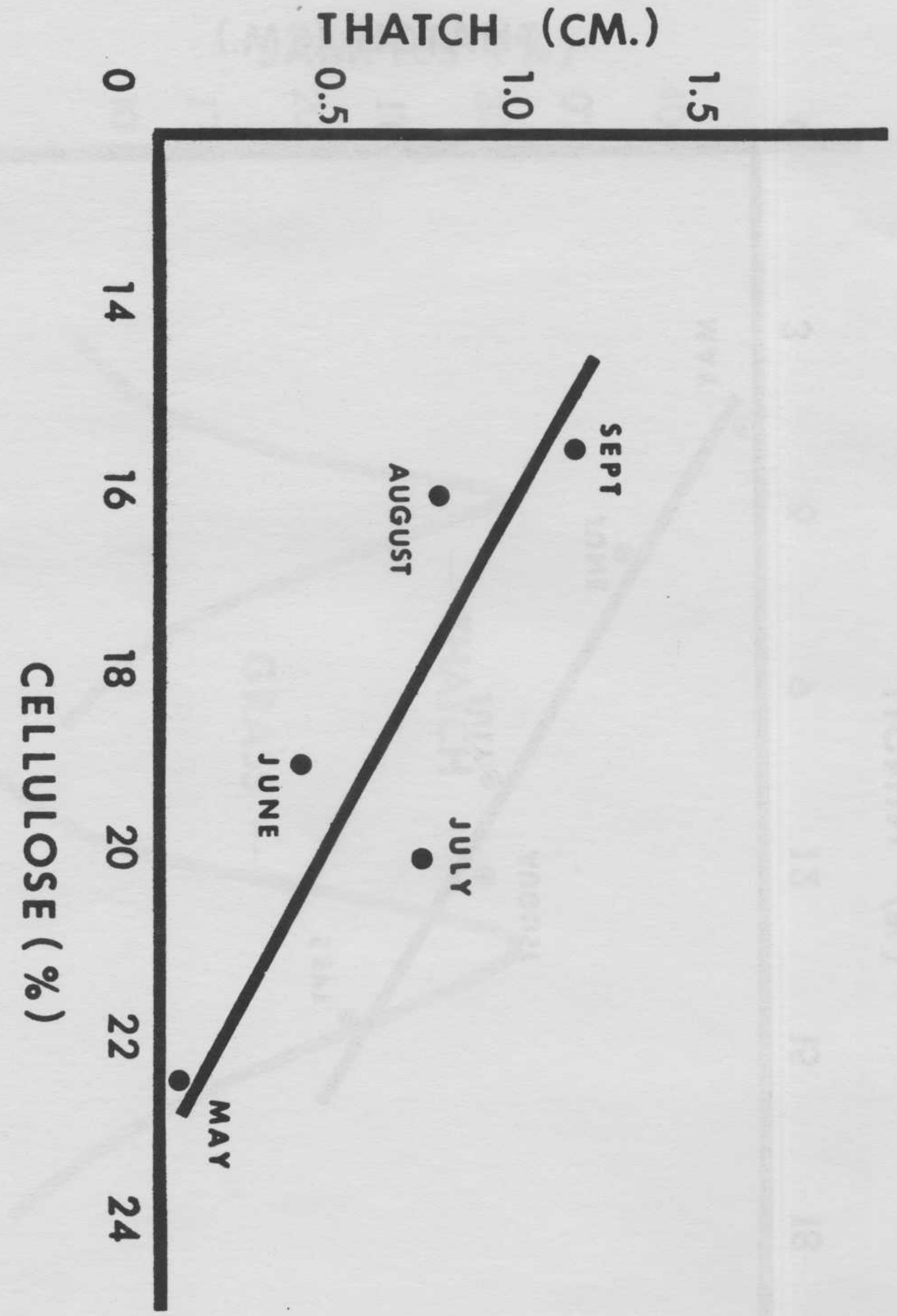
30
20
10
0
5
10
15
20
25
30
— THATCH
GRASS —
CELLULOSE (%)


THATCH (CM.)
0
0.5
1.0
1.5
3
6
9
12
15
18
MAY
JUNE
JULY
AUGUST
SEPT
LIGNIN (%)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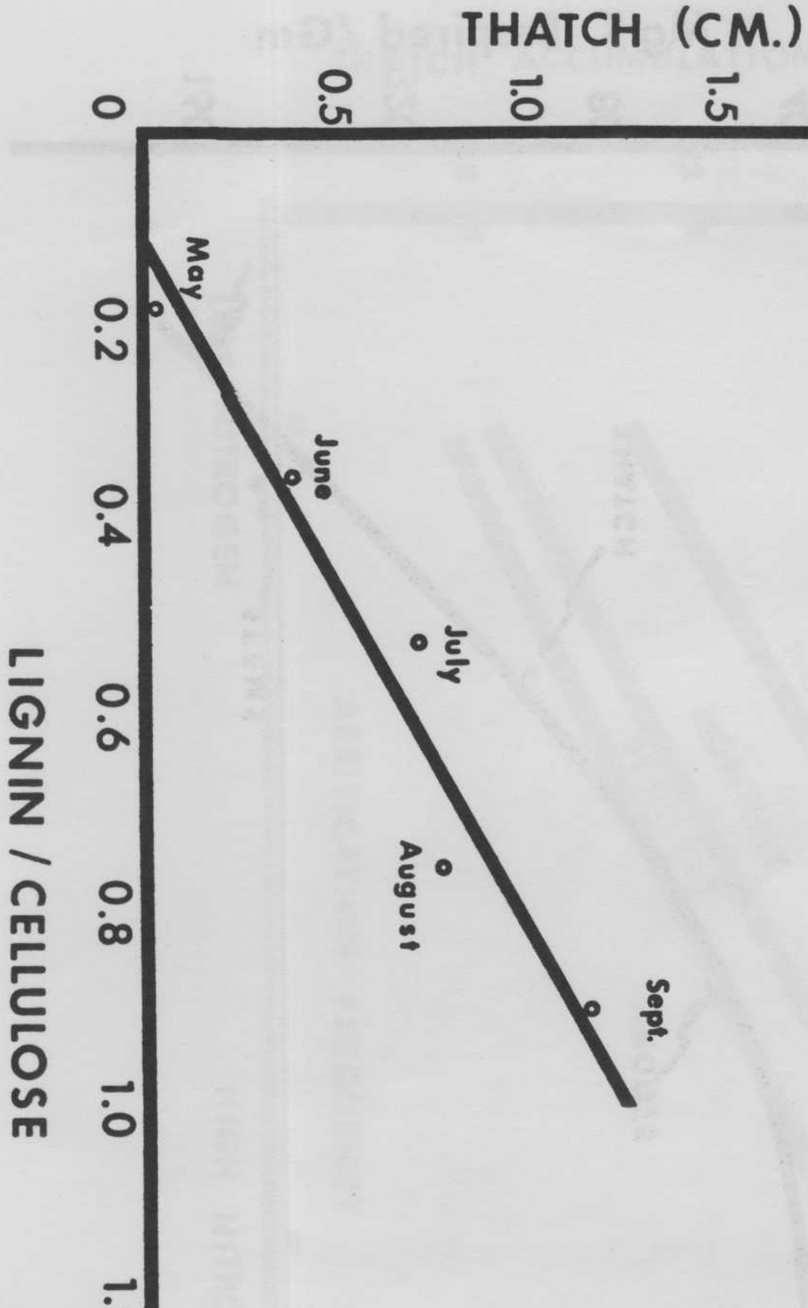
1.5
14
16
18
20
22
24
CELLULOSE (%)
SEPT
AUGUST
JUNE
JULY
MAY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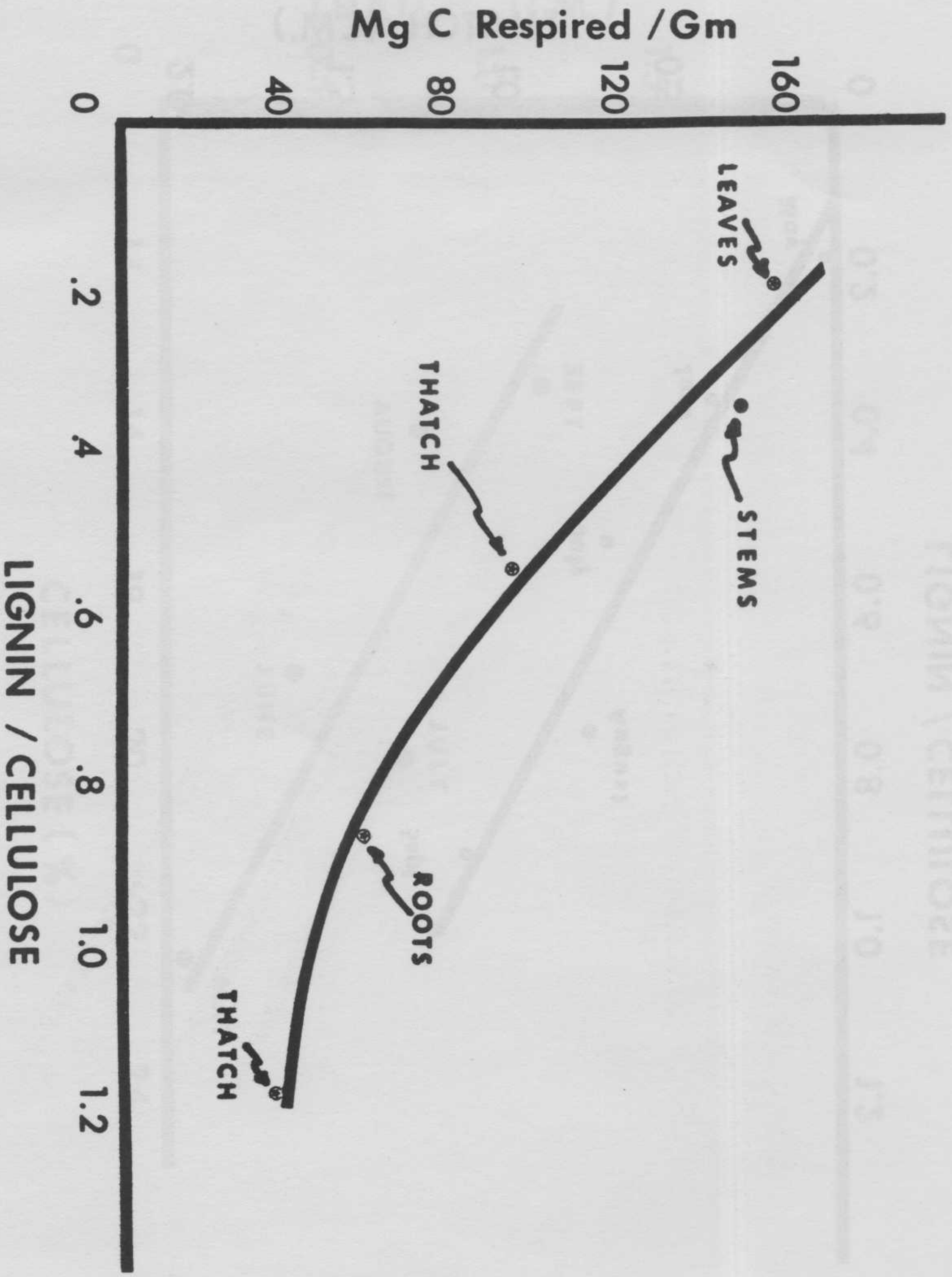
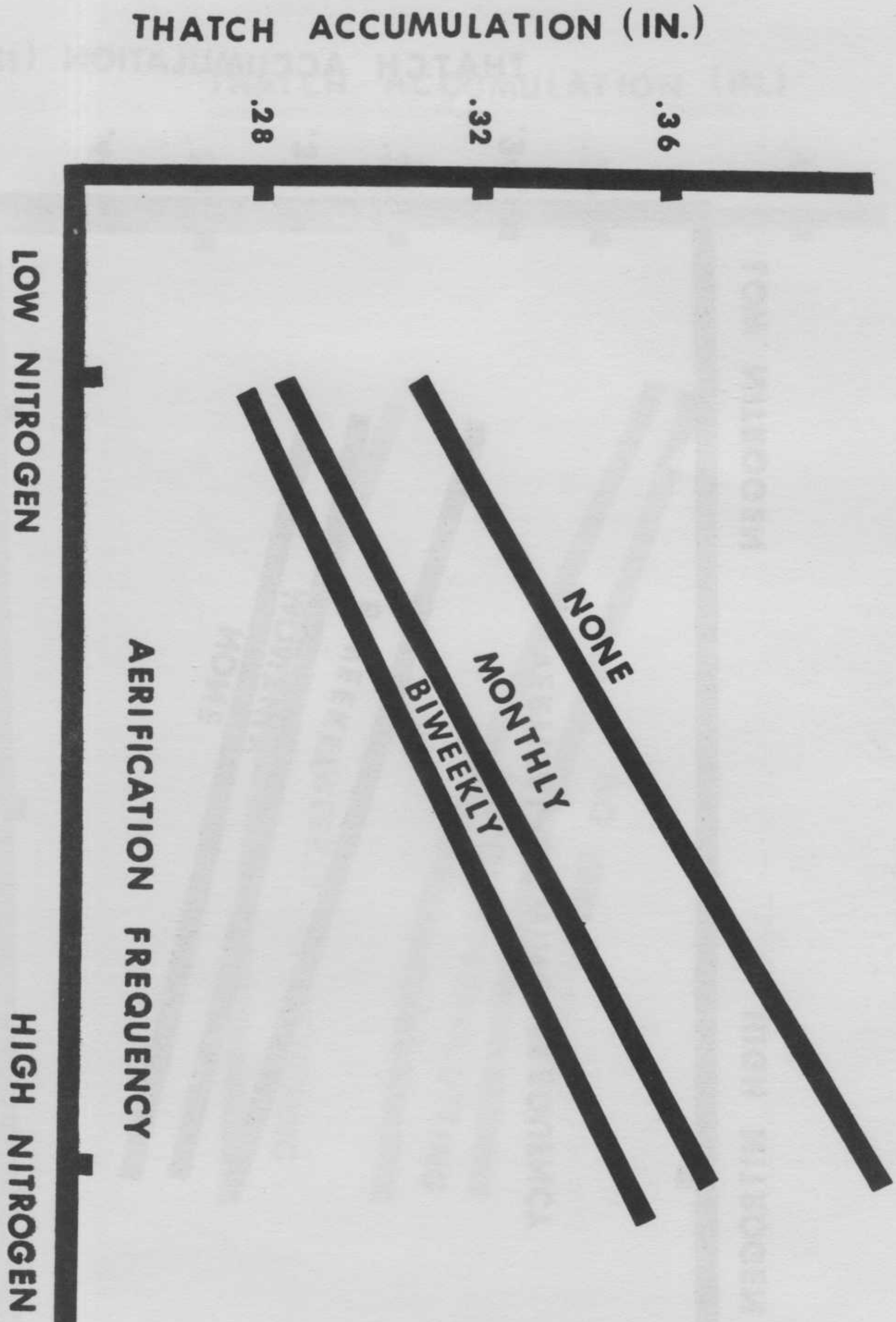
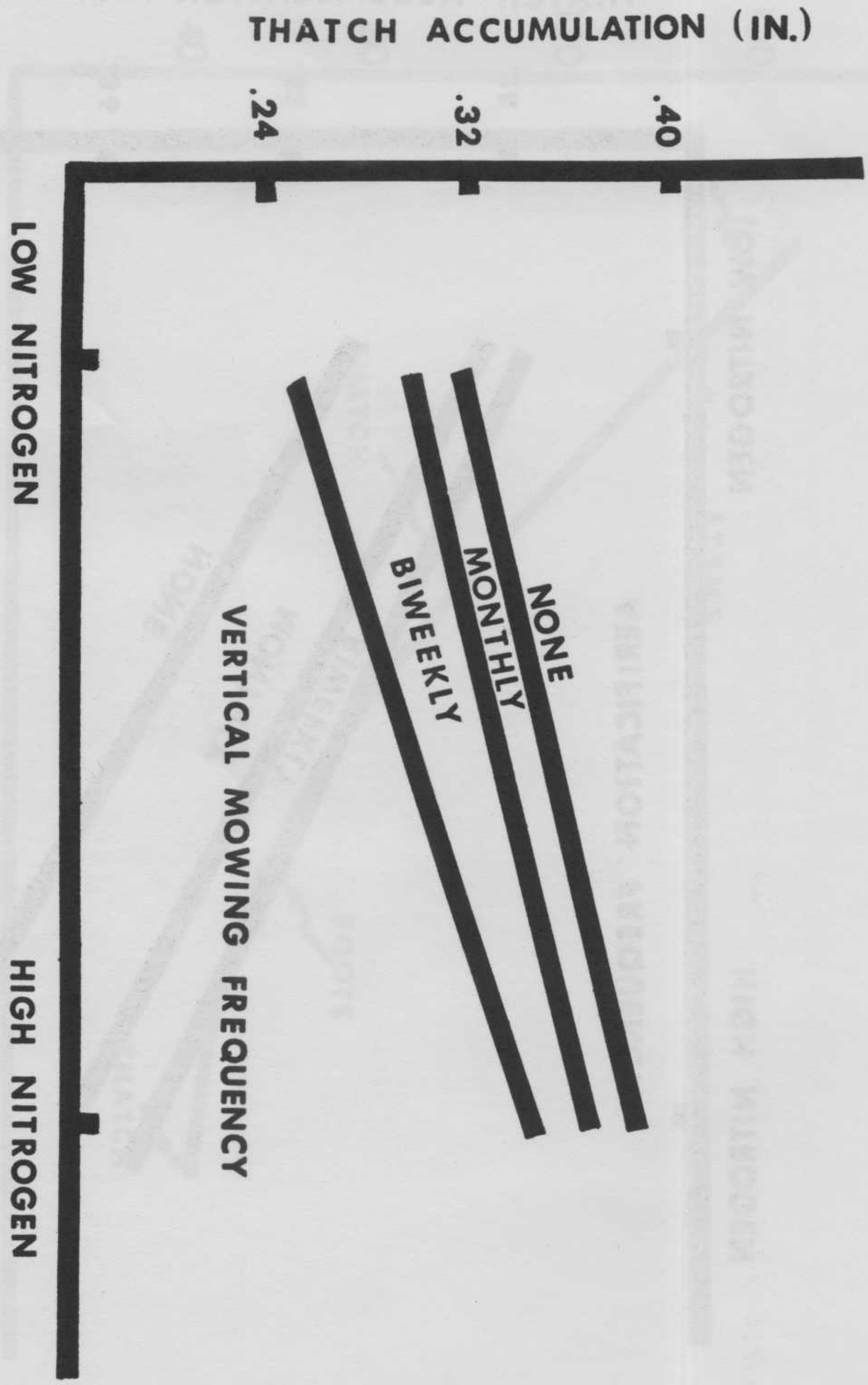
0
0.5
1.0
1.5
2.0
LIGNIN / CELLULOSE
0.2
0.4
0.6
0.8
1.0
1.2
May
June
July
August
Sept.



Mg C Respired /Gm
0
40
80
120
160
LEAVES
STEMS
THATCH
ROOTS
THATCH
.2
.4
.6
.8
1.0
1.2
LIGNIN / CELLULOSE


THATCH ACCUMULATION (IN.)
.28
.32
.36
LOW NITROGEN
HIGH NITROGEN
AERIFICATION FREQUENCY
NONE
MONTHLY
BIWEEKLY


THATCH ACCUMULATION (IN.)
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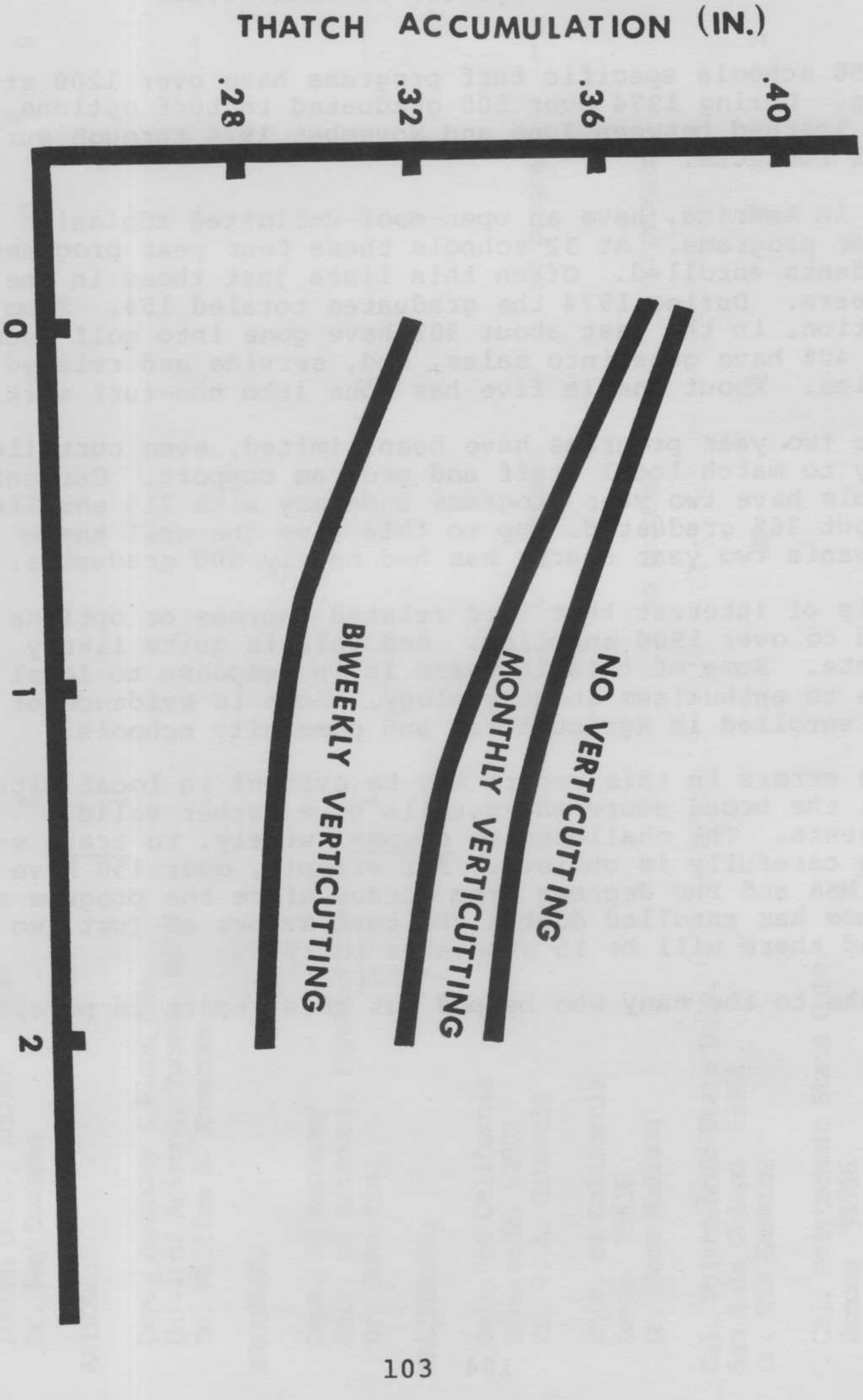
.32
.40
LOW NITROGEN
HIGH NITROGEN
NONE
MONTHLY
BIWEEKLY
VERTICAL MOWING FREQUENCY


THATCH ACCUMULATION (IN.)
.28
.32
.36
.40
AERIFICATION FREQUENCY
0
1
2
NO VERTICUTTING
MONTHLY VERTICUTTING
BIWEEKLY VERTICUTTING

UNIVERSITY/COLLEGE ACADEMIC TURFGRASS PROGRAMS

W. H. Daniel
Department of Agronomy
Purdue University
W. Lafayette, Indiana 47907

At 56 schools specific turf programs have over 1200 students in training. During 1974 over 500 graduated in turf options. That's what we learned between June and November 1974 through surveys plus personal contacts.

We, in America, have an open-door-unlimited admission in most four year programs. At 32 schools these four year programs include 495 students enrolled. Often this lists just those in the upper three years. During 1974 the graduates totaled 154. From observation, in the past about 40% have gone into golf course work. Another 40% have gone into sales, sod, service and related turf activities. About one in five has gone into non-turf work.

Some two year programs have been limited, even curtailed, recently to match local staff and program support. Currently about 29 schools have two year programs underway with 715 enrolled. In 1974 about 365 graduated. Up to this time the well known Pennsylvania two year course has had nearly 500 graduates.

It is of interest that turf related courses or options have expanded to over 1900 enrolled. And this is quite likely incomplete. Some of this increase is in response to local needs, and some to enthusiasm about ecology. Some is evidence of greater numbers enrolled in agricultural and community schools.

Some errors in this report may be evident in local situations; however, the broad scope and details give rather valid measurements. The challenge to <u>counsel</u> wisely, to <u>train</u> well, and to <u>place</u> carefully is obvious. For example, over 150 have graduated in BSA, MSA and PhD degrees from Purdue since the program started. Purdue now has enrolled double the turf majors of just two years ago. And there will be 15 graduates in 1975.

Thanks to the many who helped put this report in perspective.

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
ALABAMA:						
Dept. of Agronomy Auburn Univ., Auburn 36830 Dr. Ray Dickens	2	7	--	0	0	0
ARIZONA:						
Dept. Agronomy & Plant Gen. Univ. of Arizona, Tucson 85721 Dr. William E. Kneebone	1	10	2	--	--	20
ARKANSAS:						
Dept. of Agronomy Univ. of Arkansas, Fayetteville Dr. John King 72701	1	2	1	--	--	25
CALIFORNIA:						
Univ. of California Riverside, 92502 Dr. V. A. Gibeault	1	no program		no program	--	--
Univ. of California Davis 95616 Dr. John Madison	3	no program		no program		118
Cal. Polytechnic State Univ. San Luis Obispo 93401 Dr. Tim Gaskins		20	2	2	2	141
Cal. Polytechnic State Univ. Pomona 91766 Dr. Kent Kurtz	1	10	--	--	--	110
COLORADO:						
Dept. of Horticulture Colo. St. Univ., Ft. Collins Dr. J. D. Butler 80523		14	4	30	10	150

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
Denver Comm. College North Campus, Denver 80216 Mr. Jim O'Shea		--	--	25	10	--
Northeastern Jr. College Sterling 80216 Mr. Al Dzingle	--	--	--	15	6	--
CONNECTICUT:						
Hartford Co. Ext. Service Hartford 06105 Mr. Stanley Papanos	--	no program	--	no program	--	95
FLORIDA:						
Dept. Ornamental Hort. Univ. of FLorida, Gainesville Dr. A. E. Dudek 32601	3	2	3	--	--	--
Lake City Comm. Coll. Lake City 32055 Dr. Gene B. Nutter	--	--	--	70	30	--
GEORGIA:						
Dept. of Agronomy Univ. of Georgia, Athens 30602 Dr. Joel Giddens	1	8	2	--	--	--
IDAHO:						
Dept. Plant & Soil Sci. Univ. of Idaho, Moscow 83843 Dr. Ronald Ensign	3	2	2	--	--	25

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
ILLINOIS:						
Dept. of Horticulture Univ. of Illinois, Urbana 61801 Dr. Al Turgeon	1	20	9	--	--	59
Belleville Jr. College Belleville 62221 Mr. C. P. Friedeman	--	--	--	4	--	5
Danville Jr. College Danville 61832 Mr. Charles Schroeder	--	--	--	30	18	120
College of DuPage Glen Ellyn 60137 Ruth Nechoda	--	--	--	--	--	75
McHenry Country College Crystal Lake 60014 E. G. Solon	--	--	--	4	2	7
Kisniwaukee College Malta 60150	--	--	--	1	1	--
Dept. of Plant & Soil Sci. Southern Ill. Univ. Carbondale 62901 Dr. Herbert Portz	1	8	5	--	--	--
INDIANA:						
Dept. of Agronomy Purdue Univ., W. Lafayette Dr. D. W. Daniel 47907 Dr. R. P. Freeborg	3	50	10	--	--	80

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
IOWA:						
Dept. of Horticulture Iowa State Univ., Ames 50010 Dr. Arthur E. Cott Dr. Clint Hodges	2	20	4	--	--	--
Hawkeye Inst. of Technology Waterloo 50704	--	--	--	5	16	5
KANSAS:						
Kansas State Univ. Manhattan 66502 Dr. Ray Keen		12	4			113
Hutchinson Jr. College Hutchinson 67501 Mr. Jay Disberger	--	--	--	4	1	3
KENTUCKY:						
Dept. of Agronomy University of Ky., Lexington Dr. Hayden Watkins 40506	--	4	0	--	--	40
Eastern Kentucky Univ. Richmond 40475 Mr. Dwight Barkley	--	10	5	5	2	--
MAINE:						
University of Maine Deering Hall Orono, Maine 04473 Dr. Vaughan Holyoke	--	--	--	2	4	25

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
MARYLAND:						
Dept. of Agronomy Univ. of Maryland College Park, 20742 Dr. John Hall, Dr. Doug Hawes	1	21	3	15	13	--
MASSACHUSETTS:						
Univ. of Massachusetts Dept. of Plant & Soil Sci. Amherst, Mass. 01002 Dr. Joseph Troll	2	12	3	110	50	110
MICHIGAN:						
Dept. Crop & Soil Sci. Michigan State Univ. E. Lansing 48823 Dr. Kenyon T. Payne (2 yr.) Dr. James Beard (4 yr.)	5	35	7	85	34	30
MINNESOTA:						
Dept. of Horticulture Univ. of Minnesota St. Paul 55101 Dr. Don White	1	18	4	--	--	10
Anoka Technical Coll. Anoka 55303 Mr. Vern Hansen	--	--	--	11	14	19
MISSOURI:						
Dept. of Horticulture Univ. of Missouri Columbia 65202 Dr. John Dunn	3	7	3	--	--	--

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
MISSISSIPPI:						
Dept. of Agronomy Mississippi State Univ. Starkesville 39762 Dr. W. H. Watson	2	10	8	--	--	--
MONTANA:						
Dept. Pl. & Soil Science Montana St. Univ. Bozeman 59715 Dr. George E. Evans	--	no program	--	no program	--	60
NEBRASKA:						
Dept. Hort. & Forestry Univ. of Nebraska Lincoln 68503 Dr. E. J. Kinbacher	--	10	--	--	--	30
Technical School of Ag. Curtis 60925 Mr. R. Hald	--	--	--	15	8	--
NEVADA:						
Univ. of Nevada Reno 89507 Mr. J. E. Howland	--	--	--	6	2	--
NEW HAMPSHIRE:						
Plant Science Dept. Univ. of New Hampshire Durham 03824 Dr. Lincoln Peire, Dr. R. Emmons	1	6	2	--	--	165

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
NEW MEXICO:						
Agronomy Dept. New Mexico State Univ. Las Cruces 88003 Mr. Clarence Watson	--	11	3	--	--	--
NEW JERSEY:						
Soils & Crops Dept. Cook College, Rutgers Univ. New Brunswick 08903 Dr. R. E. Engle	6	8	2	44	20	--
NEW YORK:						
Dept. Orn. Horticulture SUNY Ag. & Tech. College Alfred 14802 Mr. Vince Smith	--	--	--	10	4	26
SUNY Ag. & Tech. College Cobleskill 12043 Dr. R. P. Smalley	--	no program	--	no program	--	52
SUNY Ag. & Tech. College Delhi 13753 Mr. Edgar L. Metcalf	--	--	--	20	15	75
SUNY Ag. & Tech. College Farmingdale 11735 Mr. Don Griffiths	--	--	--	10	10	35
NORTH CAROLINA:						
Crop Science Dept. No. Carolina St. Univ. Raleigh 27607 Dr. Bill Gilbert	3	2	6	50	17	--

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
OHIO:						
Dept. of Agronomy Ohio State Univ. Columbus 43210 Dr. David Martin, Dr. James Wilkinson	3	45	15	--	--	--
ATI Ohio State U., Wooster 44691 Mr. Jeff Lefton	--	--	--	18	7	--
Clark Technical College Springfield 45501 Mr. Dalton Dean	--	--	--	12	14	15
PENNSYLVANIA:						
Dept. of Agronomy Penn. State Univ. Univ. Park 16802 Dr. Thomas Watschke Dr. Joseph Duich	5	24	2	70	30	50
RHODE ISLAND:						
Dept. Pl. & Soil Science Univ. of Rhode Island Kingston 02881 Dr. Thomas Duff	3	12	3	--	--	--
SOUTH CAROLINA:						
Dept. of Agronomy Clemson Univ. Clemson 29631 Dr. A. R. Mazur	3	6	2	--	--	20
Georgetown Tech. Inst. Georgetown 29440 Mr. Horry	--	--	--	17	14	--

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
SOUTH DAKOTA:						
Horticulture Dept. So. Dakota State Univ. Brookings 57006	--	no program	--	no program	--	100
TENNESSEE:						
Dept. of Orn. Hort. Univ. of Tennessee Knoxville 37901 Dr. L. C. Callahan	2	17	2	--	--	--
TEXAS:						
Dept. Crop & Soil Sci. Texas A & M College Station 77840 Dr. Richard Duble	5	20	5	--	--	--
Western Texas College Snyder 79549 Mr. Gene Robertson	--	--	--	10 new program	--	--
UTAH:						
Dept. of Plant Science Utah State Univ., Logan 84321	--	no program	--	no program	--	25
VERMONT:						
Dept. Plant & Soil Sci. Univ. of Vermont Burlington 05401 Dr. Glen Wood	1	3	--	--	--	7
WASHINGTON:						
Dept. of Agronomy Washington St. Univ. Pullman 99163 Dr. Alvin Law	--	4	2	--	--	--

State, School, Contact	In Graduate Training	In 4 Yr. Program Enrolled Now	In 4 Yr. Program Grad. in '74	In 2 Yr. Program Enrolled Now	In 2 Yr. Program Grad. in '74	Related Options as Indicated in Reports
WISCONSIN:						
Dept. of Soils Univ. of Wisconsin Madison 53706 Dr. James Love	2	17	2	--	--	--
CANADA:						
Dept. Env. Biol. Univ. of Guelph Guelph, Ont., Can. Dr. Steve Fushtey	1	--	--	15	11	--
Totals	72	495	154	715	365	1955

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