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UNIVERSITY OF ILLINOIS
DIVISION OF UNIVERSITY EXTENSION

7th

Illinois

TURFGRASS CONFERENCE

PROCEEDINGS

College of Law
Auditorium

December 1-2, 1966

arranged and conducted by the

COLLEGE OF AGRICULTURE

with the cooperation of the

ILLINOIS TURFGRASS FOUNDATION

University of Illinois
Division of University Extension

Announces the

SEVENTH ILLINOIS TURFGRASS CONFERENCE

December 1 and 2, 1966
Auditorium, Law Building
Urbana, Illinois

arranged and conducted by the College of Agriculture

with the cooperation of the Illinois Turfgrass Foundation

PROGRAM

Thursday, December 1

10:00 - 12:00 noon	Registration
11:00 - 11:30 a.m.	Illinois Turfgrass Foundation Business Meeting James Burdett, President
11:30 - 1:15 p.m.	Lunch

Thursday, December 1 -- First Session

Moderator - C. O. Borgemeier, Chicago, Illinois

1:15 - 1:20 p.m.	Welcome - O. G. Bentley, Dean College of Agriculture
1:20 - 1:50 p.m.	Pesticide Compatibilities M. C. Shurtleff University of Illinois
1:50 - 2:10 p.m.	Turf Insects and Their Control Roscoe Randell University of Illinois
2:10 - 2:55 p.m.	Growing Sod on Muck Soils P. E. Rieke Michigan State University
2:55 - 3:10 p.m.	Break

Moderator - J. F. Kramer, Wilmette, Illinois

3:10 - 3:30 p.m.	How Herbicides Work E. L. Knake University of Illinois

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Thursday, December 1 -- First Session (continued)

3:30 - 4:15 p.m.	Turf Diseases and Their Control Noel Jackson Univ. of Rhode Island
4:15 - 4:35 p.m.	Question and Answer Session M. C. Shurtleff, Roscoe Randell, P. E. Rieke, E. L. Knake, and Noel Jackson
6:30 p.m.	Banquet - Colony Inn, Urbana-Lincoln Hotel

Friday, December 2 -- Second Session

Moderator - Adolph Bertucci, Lake Forest, Illinois

8:30 - 8:40 a.m.	Briefs James Burdett and Others
8:40 - 9:10 a.m.	Landscaping a Golf Course L. T. Whitlock, Jr. University of Illinois
9:10 - 9:30 a.m.	Turf Weed Control H. J. Hopen University of Illinois
9:30 - 10:00 a.m.	Site Selection for Golf Courses J. L. Holmes U.S.G.A., Chicago, Ill.
10:00 - 10:15 a.m.	Break

Moderator - James Brandt, Danville, Illinois

10:15 - 10:35 a.m.	Kentucky Bluegrass Today J. D. Butler University of Illinois
10:35 - 11:20 a.m.	Effect of Management Practices on Winter Injury to Turf R. W. Miller Ohio State University

Friday, December 2, -- Second Session (continued)

11:20 - 11:40 a.m.	Question and Answer Session
	L. T. Whitlock, Jr. H. J. Hopen J. L. Holmes J. D. Butler R. W. Miller
11:40 a.m.	Adjourn

This conference is presented specifically for persons interested in turf management by the University of Illinois College of Agriculture. Abstracts in this manual bring to you up-to-date information required by those who wish to maintain high quality turf-grass area but do not constitute positive recommendations unless so stated. Statements made herein are the responsibility of either the speaker or the institution he represents. Reproduction and publication are permitted only with the approval of each author.

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PESTICIDE COMPATIBILITIES

Malcolm C. Shurtleff

The English language is said to contain some 850,000 words--all composed from just 26 letters. The total of possible English words, using these 26 letters in all conceivable combinations, would number many billions.

At present, there are about 1,200 basic active ingredients used in pesticides (fungicides, insecticides, nematocides, herbicides, miticides, rodenticides, algacides, etc.) now registered with federal agencies in Washington, D.C. Almost 70,000 pesticide trade products, formulated in a variety of ways from these 1,200 basic chemicals, are now registered and being sold in the U.S. Not all of these, of course, are being used on turf. But with English as an example, just think of the countless trillions of possible combinations--compatible and incompatible--there are of putting two or more pesticides together in one unsuspecting spray tank to be applied to a defenseless grass! Besides pesticide combinations, soluble fertilizers and nutritional mixes, wetting agents or spreader-stickers, products to aid in water penetration or to soften "hard" water, anti-desiccants, and other chemicals ad infinitum have been added. The amazing thing is not that turf injury sometimes occurs or that a sludge forms in the bottom of the tank, but the infrequency of problems arising from these "witches brews" or "shotgun" treatments. The modern trend of mixing chemicals to apply to turf is hard to beat. As Charley Wilson, agronomist with the Milwaukee Sewerage Commission, once said, "Mixing everything in one pot seems to have more sex appeal than Brigitte Bardot."

There are three basic types of compatibility (or incompatibility):

"(1) physical incompatibility--possible settling out or poor dispersion in the tank,

(2) a chemical incompatibility--a new product is formed or breakdown of the products used, and

(3) compatibility of placement--such as a fungicide-insecticide combination where the fungicide should be on the plant and the insecticide in the soil."

As background for this talk, 90 letters were mailed to active turfgrass pathologists, agronomists, horticulturists, and extension specialists at experiment stations and universities, as well as a broad-spectrum of turf industry dealers, consultants, trouble-shooters, golf course superintendents, sod growers, and chemical company representatives from 35 states and Canada. Questions were asked concerning specific examples of where combinations of chemicals caused either incompatibility (turf injury), or reduced effectiveness. Direct replies of correspondents are marked by quotes. Those that requested credit are listed in parenthesis together with a scientific paper on the subject. A number of workers provided much of the same general material but in different terms or context. We are most grateful for the many thoughtful replies to our questions.

Over half of the turf workers indicated no concrete knowledge, reports, or follow-ups of problems resulting from the tank mixing of chemicals. Considering the wide range of environmental conditions (e.g., temperature; humidity and dew;

grass species; soil type, pH, and moisture, cultural management programs; type of water; altitude), chemicals and strengths used, and methods of application, etc. This is a truly amazing record. There are extremely few, well-documented cases of where combinations of two or more chemicals -- that are normally safe on turf when used by themselves -- has resulted in turf injury.

Now for some general principles:

1. If at all possible, apply chemicals separately. Follow the manufacturer's directions as printed on the package container as regards to dosage, method of application, and gallons of water to apply to X number of square feet of turf. Note any incompatibilities and other precautions mentioned on the label. Practically all pesticide companies and turfgrass specialists strongly recommend that pesticides be applied separately and for a specific purpose. As one correspondent noted, "Don't confuse economy in time and labor with effectiveness of the result. Somebody's job--perhaps your own--may hinge on the latter."

2. If you must mix chemicals, apply them separately to the spray tank with the agitator running. This commonly prevents "settling out" and plugging of spray nozzles. Spray solutions should be applied as soon after mixing as possible. The longer a spray combination remains in the tank, the more problems can arise.

3. Try out all new combinations in a small way on some out-of-the-way turf where a little injury won't matter. Whenever possible, include applications of the same products individually alongside the combination several times for comparative purposes. Check to see that the mixture performs all of the several functions as well as the materials applied separately. Remember, no chemical manufacturer can possibly test all of his products (as well as those of his competitors) in all possible combinations.

4. Do not mix wettable powder pesticides with emulsifiable formulations or a soluble fertilizer. Wettable powder products have a water-mix base; emulsions an oil-mix base. Such mixtures often cause "greasing" or flocculation and reduced efficiency. The "inactive ingredients" in the products--emulsifiers, solvents, surfactants, wetting agents, fillers, etc. -- are frequently the root of the problem, not the active ingredients. There are no set rules on this--it is mostly trial and error. "We see the most injury from use of emulsion rather than wettable powder formulations of insecticides, in particular." The solvent or emulsifier used is frequently the cause of turf injury. Damage is most common and severe at high temperatures.

Many researchers believe in testing a spray mix by pouring it into a Mason jar or test tube, followed by violent shaking. If a precipitate settles out within an hour or so, or "layers" develop, physical incompatibilities can be expected. Products that cause precipitation or coagulation should not be mixed in the spray tank. You can almost bet your last "Landon for President" button that reduced efficiency, nozzle plugging, or injury will result.

5. Compatibility problems are most acute when products are mixed with strongly acid or alkaline materials, e.g., sulfur, Chlordane, lime, ferrous sulphate, ammonium sulphate or nitrate. A minute or two of testing with pH paper may save you a giant headache. Don't mix alkaline and acidic materials together!

   Example: When iron (ferrous) sulphate is mixed with a product of high pH, "the iron may settle out or form agglomerates and will not supply the needed iron to the turf."

6. Store chemicals only in their original containers that are tightly closed and where contamination cannot occur. Be sure to clean out sprayers, hose lines, nozzles, and mixing containers thoroughly after each use. Follow manufacturer's directions. Numerous cases of turf injury or "incompatibility" can be traced back to contamination of equipment with potent weed-killers.

7. Don't mix a foliar fungicide or insecticide with fertilizers or other chemicals that require watering in. Remember that many disease-causing organisms and insects attack the grass blades.

8. Don't mix mercurials, inorganic and organic or phenyl, with other products (especially strongly acidic materials such as those containing sulfur, Chlordane, or chlorides, liquid fertilizers--particularly those containing phosphate or potash, and ionic wetting agents). Even using muddy or "hard" water can reduce the efficiency of organic mercury materials. See also item No. 20.

The "safening effect" of thiram on organic mercury fungicides is widely believed. PMA-thiram mixtures are known to reduce phytotoxicity to Merion Kentucky bluegrass which is sensitive to PMA, especially at temperatures above 60° to 70° F. "A water-insoluble thiram-organic mercury complex is formed in the spray tank," that "cuts down solubility and volatility of mercury and its penetration into grass leaves.---All the mercurials examined, PMA, Panogen, Emmi, Phimm, Semesan, and mercuric chloride, form water-insoluble mercurials with thiram." "In general, this is O.K. for diseases such as brown patch which occur at high temperatures but is not so desirable for cool weather diseases where it is better to use the products separately."

9. Don't mix chemicals which may be individually phytotoxic with other materials. Such combinations frequently injure grass at considerably lower concentrations than any product in the mix. Grass may also be "predisposed" to disease (brown patch) by previous applications of herbicides and nematocides, e.g., 2,4-D, Zytron, Dalapon, D-D, DBCP (Nemagon), etc. The results are not due to incompatibility per se, but rather similar to it. (Peterson, California).

10. Commercial products which are a mixture of ingredients (e.g., Ortho Lawn and Turf Fungicide or Ortho Lawn Disease Control, Tersan OM, Thimer, Kromad) "embody considerable research experience to develop. The complexity of the mixture is almost eponential and set rules are hard to come by." Many commercially-prepared mixes, that are tested by experiment stations and by golf course superintendents, are never sold due to reduced efficiency,

short shelf life, etc.

11. "The addition of soluble fertilizers to a pesticide mix can create a "Salting out" effect, impairing emulsification or suspension of other spray chemicals."

12. "Some turf injury and/or thinning (followed by weed invasion) attributed to herbicides, especially pre-emergence crabgrass controls, is actually due to fertilizer carriers used in the herbicides."

13. Turf that is in a low state of vigor (e.g., from an inbalance of N, P, K, or other elements, winter injury, excess or lack of water, poor soil mix, lack of roots, disease or insect injury) is more easily injured by chemicals and mixes than vigorous turf.

14. Buy pesticides only in amounts that you expect to consume in the current year. Different fungicides and insecticides vary in the length of time they are stable in the package on the shelf--especially once the container is opened. It also makes a difference what manufacturer formulated the product since the emulsifier, solvent, or wetting agent may be responsible for reduced effectiveness over a period of months or years. Storage conditions may be important, too.

15. Spraying early in the morning (before 7:30 AM) and late in the evening (just before or after dark) frequently results in less turf injury than during "normal" working hours.

16. "Most of the combinations I know that supposedly "safen" a compound or its formulation actually depress the effective fungitoxicity of the active ingreient." Example: certain dithiocarbamates.

17. There is also the problem of certain, exceptionally fine fungicides (e.g., zineb or maneb) inhibiting or killing fingi in the soil and thatch layer antagonistic to a disease-causing fungus (Dollar Spot). "Hence, they favor the development of an injurious fungus and increase disease." When two or more fungicides are combined they may nullify each other "by knock ing out antagonistic saprophytes. Also, to some extent it will depend upon the turf ecosystem and the "stresses" that favor a given organism at the time, and this must be taken into consideration when reporting unusual or ineffective results from conbinations." Another apparent example: Certain combinations of Daconil 2787 and difolatan are believed to predispose turf to infection by *Rhizoctonia*, the brown patch fungus (Altman, Colorado).

18. In general, "(1) Insoluble and wettable powder fungicides do not produce chemical injury unless rates far exceed manufacturer's recommendations. (2) All soluble fungicides can be phytotoxic. Each soluble fungicide has a safety factor and must be used well within the range of this safety factor. When the soluble fungicide is combined with a soluble herbicide, which also has a safety factor, the phytotoxicity is increased."

19. "Pre-emergent herbicides are usually insoluble, wettable powders and can release sufficient soluble toxins to be of concern. Soluble herbicides are all dangerously phytotoxic and have to be used well within the safety factor limit and should never be combined with soluble fertilizers."

20. PMA-cadmium nitrate mixtures with nitrogen were injurious in western Washington under cool, moist conditions. Phytotoxicity increased as the nitrogen content increased and where iron sulphate was added to certain mixes. Chelated iron also decreased control with Tag-Caddy combinations (C. J. Gould, Plant Disease Reporter 49: 923-27. 1965).

21. Now on the positive side. The following are some of the "normal spraying mixtures" of a leading golf course superintendent in the Chicago area which he considers "to be conservative." Mixes A, B, and C are applied to putting greens and D to fairway turf.

A. For 36,000 sq. ft. of bent turf

6 lbs.	Chlordane (50%)
6 lbs.	thiram (75%)
6 lbs.	zineb
1 lb.	Calo-clor
2 lbs.	iron sulphate
16 ozs.	spreader-sticker
300 gal.	water

B. For 36,000 sq. ft. of bent turf

12 lbs.	Dyrene
6 lbs.	Chlordane (50%)
2 lbs.	iron sulphate
16 ozs.	spreader-sticker
300 gal.	water

C. For 30,000 sq. ft. of bent turf

2 pkgs.	Acti-dione-Ferrated
16 ozs.	spreader-sticker
300 gal.	water

D. For 4 acres of fairway turf

4 pkgs.	Acti-dione-Ferrated
1 pkg.	Acti-dione-RZ
300 gal.	water

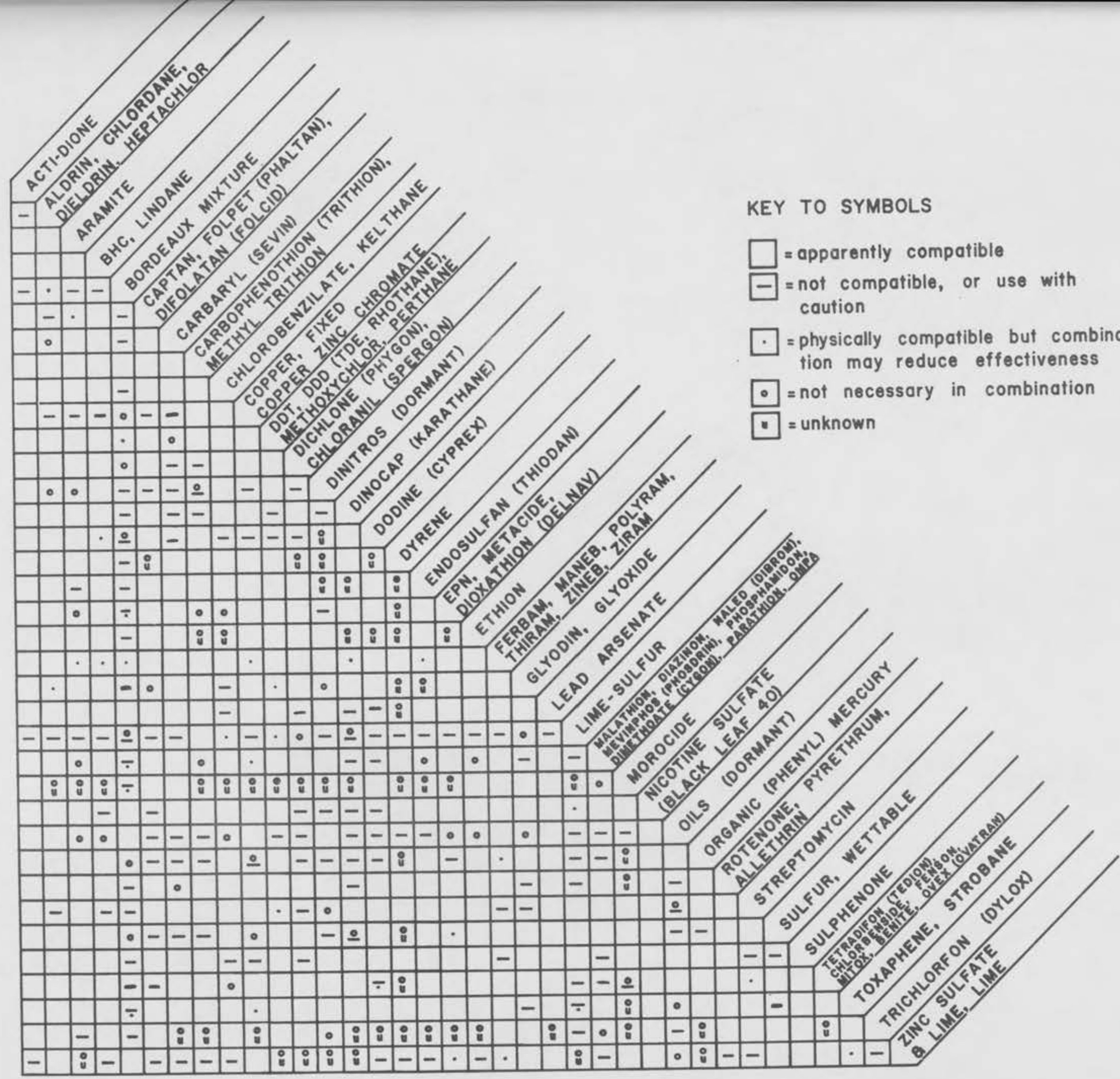
"The Chlordane is only used once a month and never in combination with Acti-dione as per manufacturer's recommendations."

22. The question, "Why don't fungicide manufacturers make up compatibility charts to guide us on what can and cannot be mixed together?" has been asked many times. Part of the answer lies in the points discussed above. We simply don't have enough information for such charts to be of much value, especially for turf. Having said this (and exposing a long, stuck-out neck), we have included a chart whose information has come from thousands of sources--state, federal, and commercial--based on countless experiences in the field on a wide range of plants. Use it for whatever value you feel it has. (Taken from How To Control Plant Diseases, 2nd edition, November 1966, Iowa State University Press, Ames, Iowa)

COMPATIBILITY CHART FOR FUNGICIDES, INSECTICIDES, AND MITICIDES

How To Use This Chart

Use as you would a road mileage chart. For example, if you wish to know whether captan may be safely combined with DDT, read down the vertical column headed "captan" until you come to the horizontal column makred "DDT, etc." The □ sign where the two columns meet tells you that captan and DDT may be used together safely. Warning: Do not mix fungicides in wettable powder form with liquid concentrates of insecticides.



KEY TO SYMBOLS

- [ ] = apparently compatible
- [—] = not compatible, or use with caution
- [·] = physically compatible but combination may reduce effectiveness
- [o] = not necessary in combination
- [u] = unknown

SOD WEBWORM INFESTATION IN RELATION TO TURF GRASS MANAGEMENT

Amal C. Banerjee and Roscoe Randell

The growth and development of bluegrass are directly affected by various environmental conditions among which are temperature, moisture supply, fertility, and conditions of the soil. Among the environmental factors, drought during the growing season is claimed to be a chief factor causing severe damage to the grasses. Insufficient rainfall accompanied by high summer temperatures causes severe injury to the turf and the only certain remedy suggested is artificial watering.

Field observations indicate that sod webworms damage to grasses may become severe when the grasses are unable to recover quickly. Especially in summer when rainfall is scanty and when plant food is insufficient to permit rapid, thrifty growth, the sod webworm may consume practically all the growth as fast as it appears, thus leaving no green on the lawn.

There are usually several species common in a locality which become active during one part of the year or another. The species of Crambus are known to be very much alike in their habits. Nearly all these insects are known to feed on grasses. Among the nearly 100 species of these insects in the U. S., about a dozen have been frequently recorded as being of economic importance, the remainder attack grasses of little or no commercial value or are relatively less abundant having no obvious economic importance.

The sod webworm injury is rarely caused by a single species. It is rather brought about by a complex of several species which are more or less spread out through the season. Several species and additional generations of the same species follow one another so that at any time throughout the growing season these pests may be found actively at work. As a general rule, each species is most destructive at a different time from the other species of that locality; hence, species of webworms prey upon the grass as a succession of small armies. If the damage caused by these insects came at one time in the year, their destructive powers would be better appreciated. Although the sod webworms take a yearly toll of lawns and golf courses, no accurate estimates are available on the losses caused by them alone. According to the USDA (Losses in Agriculture Handbook No. 291, USDA, 1955) insect pests cause estimated average annual losses of at least 5 percent to lawns, golf courses and other turf areas or about $800 million. That the sod webworms could be among the contenders in these insect pests might not well be a gross understatement.

Kentucky blue grass is a "cool weather" grass as distinguished from "warm weather" grasses such as Bermuda, Bahia and other southern types. Blue grass is physiologically adjusted to a lower optimum temperature. In fact, its internal mechanisms seem to suffer when temperature remains persistently above 85°F. Catabolic losses mount up rapidly at higher temperatures while photosynthesis does not increase proportionably. The net result is an operative loss for blue grass during the hot weather. Kentucky blue grass is known to be at its glorious best in the seasons when temperatures range between 55° and 80° F. Hence, any dry condition or continued dry spell during the hot months of the summer when webworms buildup their population and are actively feeding will obviously result in severe damage of the grass.

Field observations and emergence records on the larvae and pupae collected from blue grass lawns in this area indicate a numerical preponderance of <u>C. trisectus</u> commonly referred to as leather-colored sod webworm or larger sod webworm. On this account this investigation has been conducted only on this species of webworm.

It is present throughout the season; the larvae do thier destructive work not only in spring, but through the whole summer and even in fall (Slide). They overwinter as partially grown larvae. In spring they feed on the grass and complete their growth, pupating in their silken tunnels. In late May or early June the moths emerge, mate and lay their eggs. The female moths may lay in the amount of 500 eggs in her lifetime. From the time it appears, it is continually present through the season. Two complete generations are possible--the first generation from the middle of May to the middle of July and the second generation from mid-July to the middle of September. Depending on the seasonal conditions, the eggs of the third generation are laid in the latter half of September. The larvae of the 3rd generation become only partially grown through the second week of October when winter comes and the insect goes into hibernation.

The damage done by the 1st generation in spring may not be severe since the insects are present in fewer numbers and also since spring conditions are generally favorable for grass growth. The insects are most abundant during the summer months. From the middle of July when the second generation larvae are found actively feeding, the insects occur in great abundance through the early part of September. It is during this time the larvae become most injurious to grasses. It is obvious that the high temperatures of summer accompanied by insufficient rainfall and a continued dry spell during the active feeding period of the insect may greatly intensify the injury to grass.

Keeping this situation in mind, the experiments were designed to collect quantitative data on the consumption of the blue grass by webworm larvae and to correlate this information with the growth of yields of blue grass under different environmental conditions. Until about half grown, the larvae skeletonize the leaves and the total amount consumed during that part is not very significant. The larvae are most voracious during the stage just before pupation. At this stage (which may continue for 10 days) a larva can consume about 7 linear feet of leaf on the average. The equivalent amount by weight is about 0.4 gram. This accounts for about 70% of the total consumption during the life of a larva.

To correlate this knowledge to the growth and yield of grass, Kentucky blue grass was grown from June 9 to September 1, 1966 under the following experimental conditions:

1. Poorly watered (0.7 inch per week)
2. Well watered (2.0 inches per week)
3. Well watered + 3 applications (once a month) of fertilizer
4. Well watered + 6 applications (twice a month) of fertilizer

2 X 1 foot plots of Kentucky blue grass sod were used in each of the four experiments. Each treatment was replicated 9 times. All plots were sampled once a week by clipping off the top growth at a 2 inch height from the ground. The plots were watered with the desired amount once a week. The top growth was removed, dried, and its gram weight was recorded.

The data doesn't indicate significant increase in the yield when the application of fertilizer is in excess of once a month. Yield is nearly doubled when well watered (2 inches per week) and fertilizer is applied once a month at the given rate.

When well watered and properly fertilized, a square foot area of blue grass lawn may carry 5-6 larvae to show 50% damage; whereas in a poorly watered and improperly fertilized lawn 2 to 3 such larvae may cause the same amount of damage. These experiments also indicate that depending on the management of blue grass lawns that with the detection of 1 to 3 larvae/sq. ft. area or indication of damage to blue grass to the extent of 25% or less warrants chemical control.

The 1967 chemical control suggestions for lawn insects are on next page.

CONDENSED INSECTICIDE RECOMMENDATIONS FOR LAWN INSECTS

Insects	Insecticide[1]	Dosage per 10,000 Sq. Ft.[2]	Suggestions
True white grubs (NHE-23) Annual white grubs (NHE-23) Japanese beetle larvae (NHE-32) Green June beetle larvae Ants (NHE-111, Cir. 887)	chlordane dieldrin	2 lb. 8 oz. 12 oz.	Provides 5-year protection. In established sod, apply as granules or spray, and water in thoroughly. For seeding, mix in soil before seeding. Do not plant vegetable root crops in treated soil for 5 years.
Ants (NHE-111, Cir. 887) Cicada killer (NHE-79) and other soil-nesting wasps (NHE-17)	diazinon	1 lb.	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest after dark. Seal in with dirt.
Earthworms	chlordane	2 lb. 8 oz.	As for grubs. Control seldom necessary.
Lawn webworms (NHE-115)	carbaryl diazinon	2 lb. 1 lb.	As sprays use at least 25 gal. of water per 10,000 sq. feet. Do not water for 72 hours after treatment. As granules, apply from fertilizer spreader.
Armyworms (NHE-21) Cutworms (NHE-77) Chinch Bugs (NHE-35)	carbaryl	8 oz.	As sprays or granules. Use 5 to 10 gal. of water per 10,000 sq. ft.
Leafhoppers (NHE-22)	carbaryl methoxychlor	8 oz. 4 oz.	As a spray.
Millipedes and sowbugs	As for webworms.		
Mites (NHE-58)	Kelthane malathion	2 oz. 6 oz.	Spray grass thoroughly, 20 to 25 gal. of water per 10,000 sq. ft.
Chiggers	diazinon	8 oz.	Spray grass thoroughly. Use at least 10 gal. of water per 10,000 sq. ft.
Slugs (NHE-84)	Slug baits	Scatter in grass.	Where slugs are numerous

1/ The following insecticide formulations commonly contain these amounts of active ingredients by weight. Carbaryl, 1 ¼ lb. of 80% W.P. contains 1 lb. actual carbaryl; chlordane, 1 gal. of 45% E.C. contains 4 lb. actual chlordane; diazinon, 1 gal. of 25% E.C. contains 2 lb. actual diazinon; dieldrin, 1 gal. of 18.6% E.C. contains 1 ½ lb. actual dieldrin; Kelthane, 1 gal. of 18.5% E.C. contains 1 ½ lb. actual Kelthane; malathion, 1 gal. of 50-57% E.C. contains 5 lb. actual malathion; methoxychlor, 1 gal. of 25% E.C. contains 2 lb. actual methoxychlor.

2/ Amount per 10,000 square feet (¼ acre) is in terms of the active ingredient. Do not allow people or pets on lawn until spray has dried.

GROWING SOD ON MUCK SOILS

P. E. Rieke

Sod is defined by Webster as the covering of grass with its matted roots forming the surface of grassland. For our purposes we can extend this definition to include that segment of sod which is established and maintained by man as a commercial crop to be harvested, sold, transported, and delivered to another location where it will be laid and maintained for beautification and/or use.

Sod production has grown into a major industry within recent years. This, in fact, is the fastest growing agricultural industry in Michigan; about 5,000 acres in 1960 to over 20,000 acres in 1966. This growth has come in response to demand for sod by the public. The acceptance of sodding for quality turf (instant grass) by the public as well as a favorable economic climate have played major roles. Favorable soil and climatic conditions plus experience in sod production over a period of years make it possible to produce high quality sod. It has been estimated that 50-70% of the sod produced in Michigan is exported to surrounding states.

There are several key requirements for development of a successful sod farming enterprise. These include: 1) availability of adequate capital, equipment, and labor; 2) a soil that is suitable for sod production; 3) adequate technology in the establishment, maintenance and harvesting operations; 4) development of a market for your product; and 5) integrity to produce a desireable product capable of giving satisfactory turf in the location where it is to be used.

Sod production is an intensive farming enterprise requiring an understanding of the technology sufficiently well to know the costs of investment and labor. The seasonal labor demand is a critical factor. In most cases the tendency has been to underestimate costs. Actual figures vary widely depending on the size of the operation planned, necessary land improvements and marketing costs.

<u>Soil Selection</u> -

About three-fourths of the sod produced commercially in Michigan is grown on organic soils. Particularly, the largest producers are operating on these soils. They are smooth, relatively flat areas free of stones because of the nature of their formation. The sod produced is of considerably lighter weight than that from mineral soils, facilitating easier handling and laying, and results in lower transportation costs. Generally, a crop can be produced in 6 months less time than on mineral soils.

On the other hand, organic soils are poorly drained and normally require artificial drainage and water control. In many cases drainage water must be lifted by pumping into the drainage outlet. During periods of peak rainfall, the soils may not be stable enough (due to water saturation) to support maintenance and harvesting equipment. This necessitates special flotation equipment such as ballon tires and extension rims on equipment and trucks. A few growers even use special conveyers to move the sod to solid ground where trucks can be loaded. Graveled roads may be an alternative, but an expensive one.

On some farms the poor drainage and tiling needs have been used to advantage by practicing subirrigation. This means backing water into the tile to maintain the water table at a 2-3 foot depth. This provides some water for the grass, but it also reduces the tendency for organic soil to subside, or shrink.

On some of the organic deposits in Michigan, it is necessary to remove undecomposed sticks and stumps previous to seeding. Each tillage operation brings up more debris. However, most growers are located on land previously used for vegetable production which is already cleared. Some of the growers have found it necessary to clear more land in order to expand operations.

The question is often raised as to how much soil is removed with a crop of sod. An experiment on our Muck experimental farm has shown no difference between cropping and sod production over a three year period in their effects of soil level. Neither crop reduced the soil level significantly below that of a continuous grass plot. Over a period of years, however, it is recognized that an appreciable amount of soil will be removed. The soil underlying the organic soils in Michigan are generally undesireable for sod production or most any other crop. As a result, when the organic soil depth reaches about 12 inches it would be advisable to change to some other enterprise in which soil is not removed.

An adequate source of good water is almost essential for an intensive operation. Some growers are fortunate enough to have access to a stream, but in most cases a deep well is necessary to get the capacity for irrigating a large acreage at a time.

Accessibility to good highways and potential markets are factors which should also be considered.

Establishment -

Since obtaining a uniform stand is essential, good establishment techniques are also essential. Many tillage methods have been used in soil preparation, most of which include plowing as the initial step. The soil should be worked down and carefully leveled with a special leveling device. This is a very important step since an uneven surface normally results in a longer period before harvest.

For new sod fields or those infested with weeds, a summer fallowing may be necessary. Allow about 2 week intervals for weed seeds to germinate before tilling again.

If weedy perennial grasses, such as quackgrass, are present, an expensive eradication program will be necessary. Be alert for fields contaminated with nutgrass since there is no effective control for this weed.

The most favorable seeding time in Michigan is August 15 to September 15 (taking advantage of the periods of desireable rainfall). Spring seedings are less favorable because of competition with weeds and the approaching hot weather. Dormant fall seedings (from mid-November to freezing) are often successful if the land is not subject to overflow in the spring. Growers who have ready irrigation facilities have been able to seed at any time during the growing season with no difficulty.

Most sod produced in Michigan is 100% Merion bluegrass. However, public awareness and good educational materials used by landscapers and sod growers are leading to increased demand for grass mixtures. Particularly important is a component of red fescue if sod is to be used in shady areas. Blends of bluegrasses generally have exhibited greater disease resistance as well.

Seeding rates recommended currently in Michigan are as follows:

Kentucky bluegrasses	25-40 pounds per acre
Red Fescues	60-100
Mixed bluegrasses, and red fescues	35-65

Actual rates will depend on germination and purity of the seed, condition of the seedbed, time of year, availability of irrigation, and personal preference. Be sure to purchase good quality, clean seed.

For seeding, the Brillion seeder is most widely used although a cyclone seeder followed by a cultipacker is also used successfully. Other establishment techniques have been tried, but most have not been successful on a large scale basis as yet.

Lime and seedbed fertilizer should be applied as suggested by soil test and worked into the soil. If the pH of the organic soil is below 5.5, lime should be added to the soil before preparation.

Nitrogen can be mixed in the seedbed at the rate of 50 pounds per acre for spring and 30 pounds per acre for fall plantings. The phosphorus and potassium requirements for Merion bluegrass are currently being studied at Michigan State University. Perliminary data indicate Merion (as most grasses) are very efficient feeders of phosphorus and potassium. The current phosphorus and potassium recommendations for Michigan are shown in the following tables. Our recommendations are designed to insure that these nutrients are not a limiting factor.

PHOSPHORUS RECOMMENDATIONS

Available soil P* pounds per acre	P_2O_5 recommended pounds per acre	P recommended pounds per acre
10	160	70
20	130	57
40	100	44
70+	50	22

*Soil tests are based on methods used in the State Soil Testing Laboratory, Michigan State University (Bray P_1 - phosphorus and Ammonium acetate extractable-potassium).

POTASSIUM RECOMMENDATIONS

Available soil K* pounds per acre	K_2O recommended pounds per acre	K recommended pounds per acre
100 or less	200	166
150	160	133
200	130	108
250	100	83
300	50	42
400	0	0

*Soil tests are based on methods used in the State Soil Testing Laboratory, Michigan State University (Bray P_1 - phosphorus and Ammonium acetate extractable-potassium).

Maintenance -

Nitrogen fertilization subsequent to establishment is also under study at the present time. Too high rates of nitrogen have been found to weaken the sod and increase the time to harvest for Merion bluegrass. The high nitrogen rates apparently stimulate top growth at the expense of root development. Thus top growth may not necessarily be a good indicator of good sod formation since a tightly knit sod is dependent on the formation of a dense mat of roots and rhizomes. The current nitrogen recommendations for Michigan conditions are given below.

Annual maintenance nitrogen recommendations in pounds N per acre for organic soils.

Merion Bluegrass	Common Kentucky Bluegrass	Red Fescues
120-180	80-120	40-75

Other factors to consider in determining the nitrogen needs include the appearance of the grass, the time of year, amount of irrigation (and leaching), and the rate of release of nitrogen from the organic soil.

Nitrogen is usually applied in 4 to 6 week intervals during the growing season with a maximum of 60 pounds per acre for any one application for Merion, and 40 pounds for the other grasses after May 15. Nitrogen can also be applied when the ground is still frozen if the land is not subject of overflow. Less nitrogen should be applied during hot, dry periods especially if irrigation is not available. Reducing growth of the grass by holding back nitrogen to the point where it is limiting, however, will likely reduce the rate of sod development.

A mowing height of 1½ to 2 inches is preferred. Mowing height studies have indicated that mowing above 2 inches may reduce the strength of the developing sod. Further studies are necessary before definite conclusions can be made, however.

Irrigation is nearly essential for intensive operations. Proper timing with rainfall will help to keep the grass in the vegetative phase during hot weather when it tends to become dormant. This requires an adequate water source and a working knowledge of the soil and crop needs.

On occasion it may be necessary to remove clippings by sweeping during periods of peak growth or following an extended period during which the grass could not be mowed. General recommendations for mowing suggest to remove not more than 1/3 of the top growth at mowing time.

Control of insects, diseases, and weeds should be carried out as need occurs. Diseases, especially, may be a serious obstacle during some years.

Harvesting -

The sod can be harvested as soon as the root and rhizome system has become dense enough to handle the sod pieces without tearing. The dept of cut varies from 3/8 to 5/8 inch for bluegrass or red fescue sod. Much of this volume is actually occupied by the root mass. Sod which is cut thinner is lighter weight, handles easier, lays better and knits better than thicker-cut sod under desireable moisture conditions. The thicker sod will not dry out as rapidly, however.

Sod grown on organic soil will knit at least as well as sod grown on mineral soils under desireable environmental conditions. There are places where mineral soil sod is to be preferred, of course, such as football fields where the playing surface will be subject to considerable stress.

Heating of the sod while rolled or piled is a very critical problem, especially during warm weather in June when seedheads form readily. Techniques such as harvesting early in the morning before the soil warms up or vacuum cooling the sod have been used to combat the problem. The factors affecting sod heating are currently under detailed study at Michigan State University.

The use of sod cutters, sod rollers, conveyors, and pallets have improved the harvesting operations considerably. Some of these pieces of equipment are commercially available now; others are currently being developed by individuals or companies. Innovations in these and other areas of production require considerable ingenuity and investment.

Market Development -

This, perhaps, is the most important step in the development of a successful enterprise. Overplanting without a good market indicates poor planning. A good contract with landscapers, nursery and garden centers, for example, provide important outlets. For Michigan growers this means making out-of-state contacts for new growers or for expanded operations.

Future -

The future is always of interest, but not always so predictable. Certainly growers will become more efficient and more specialized as should be true in any business. There will be continued innovations throughout the production and marketing phases which will be contributed by the pioneers of the industry.

Research will play a key role in developing and understanding better management practices. Improvement in the image of sod and sales promotion techniques are essential to continued growth. These kinds of factors will require special training and experience to be able to compete in this highly specialized, modern agricultural business.

HOW HERBICIDES WORK

Ellery L. Knake

In the past, major effort has been on screening thousands of compounds to find ones with herbicidal activity. Less effort has been devoted to finding out why or how they work. As we develop a greater body of fundamental knowledge, we will hopefully be able to more adequately characterize and codify the morphological and physiological differences between plant species. Then we should be able to more logically proceed with the development of specific chemicals to affect specific reactions in plants.

At present we have a few classic examples of the basis for selectivity (why a herbicide kills some plants and not others). When 4-(2, 4-DB) is applied for control of certain broadleaved weeds in forages it is changed in some weeds to 2,4-D and thus kills them. However, it does not kill the legume crop because this plant does not have the same mechanism for converting the chemical to 2,4-D.

Triazine herbicides are highly selective for controlling weeds in corn. Corn is tolerant because the herbicide is inactivated by physiological processes in the corn plant. Most annual weeds do not effectively metabolize or change the triazine to an inactive substance and are thus killed.

Dalapon acts by inhibiting the enzymatic synthesis of pantothenic acid, a B-vitamin essential for plant growth. Normally beta-alanine and pantoic acid are coupled together by an enzyme to produce pantothenic acid. When dalapon is present it competes with pantoic acid to prevent the formation of essential pantothenic acid.

Although 2,4-D is one of our oldest selective herbicides, we still do not have a thorough understanding of its specific action. We can merely describe its action in terms of the physiological and morphological effects it has on plants. Physiological effects are likely primary. Morphological changes which might be thought of as "clogged plumbing" in the plant are probably secondary.

Now that you feel either educated or confused, let's consider some of the factors affecting herbicide performance. By considering some of these factors when selecting and applying herbicides, you may be able to achieve greater success.

Whether the herbicide is applied to the soil or to the foliage it is desirable to have sufficient retention, penetration, and absorption. Don't spray just before a rain so the herbicide is washed off. On the other hand, too rapid drying may leave some herbicides as crystals on the leaf surface so that penetration and absorption is reduced.

Herbicides enter plants through a waxy cuticle on the leaf surface. The thickness and nature of the cuticle varies, depending on the plant species, age of the plant, and environmental conditions. Young plants have thinner cuticles than older plants so it's usually best to spray weeds when they are young. Plants growing under hot dry conditions will have thicker cuticles than those growing in the shade under moist conditions.

Esters of 2,4-D are formulated with oil and an emulsifying agent. They usually penetrate the cuticle a little easier than most other forms of 2,4-D and being oil-like, tend to resist washing from the plant a little better.

Amine salts of 2,4-D are water soluble but not generally soluble in petroleum oils. However, some oil soluble amines are now formulated. The esters and oil soluble amines penetrate the waxy cuticle more readily and can be used at lower rates than the amines. But when rates are properly adjusted, there should be little difference in weed control from the esters or amines. Although esters may penetrate a little faster, six to twelve hours before a rain is usually adequate for effective weed control with either formulation of 2,4-D. The amines have the advantage of being less volatile, and therefore, safer than esters in the vicinity of susceptible desirable plants.

Care should be exercised with surfactants, wetting agents, emulsifiers, detergents, spreaders, sticking agents, and dispersing agents. Although they may increase effectiveness on the weeds, they may also increase damage to the desirable plants sprayed at the same time.

After the herbicide penetrates the cuticle and is absorbed by the plant, it may translocate, or move in the plant. Translocation may occur upward and downward. It is important for getting the herbicide to the effective site of action. The rate and amount of movement depends on the plant species and environmental conditions. It is usually best to spray when weeds are actively growing. For some perennials it is best to wait until about the bud stage. By this time food reserves from the roots will have been fairly well depleted by the new top growth and new food reserves will be moving from the leaves to the roots. The 2,4-D can move with the food supply to the perennial roots and thus be more effective.

The activity of herbicides may be lost or inactivated by decomposition, volatility, leaching, adsorption onto the soil complex, and breakdown by microorganisms. If the loss is too rapid, adequate weed control may not be obtained. These factors can be controlled to some extent. For example, incorporation or watering after application of volatile soil applied materials can help to reduce loss. Excessive leaching may be avoided by not watering excessively.

One of your main interests is with soil applied preemergence herbicides. At present there is some controversy about incorporation of these materials. In established turf there is usually little or no opportunity for incorporation by physical movement of the soil. In general, excessive incorporation by physical means or by watering is not desirable for the more soluble herbicides which may be leached too deep.

The best placement for herbicides is logically in position closest to the effective site of uptake by the species to be killed. It has commonly been stated that preemergence herbicides should be located near the germinating weed seed. Since the herbicide was applied to the soil, it has often been assumed that root uptake was of primary concern. However, recent research by several investigators indicates the importance of shoot uptake. The site of effective uptake varies for different species and different herbicides. It appears that Tupersan is effective through the roots of crabgrass. With green foxtail Treflan appears to be most active through the emerging shoots.

It appears that shoot uptake of some herbicides by young emerging seedlings is quite possible and in some cases even the major means of entry. The cuticle would not be well developed and the moist microclimate in the soil should be conducive to absorption by the shoot. Where shoot uptake is the primary means of entry, surface application or very shallow incorporation would seem desirable rather than deeper or subsurface placement. Shallow placement, particularly with sufficient soil moisture, should help to avoid dilution and keep the herbicide in position for the shoots to grow through it.

Further research and delineation of differences in effective site of uptake for the major turf species and turf herbicides may suggest placement methods helpful for increasing selectivity.

DOLLAR SPOT DISEASE AND ITS CONTROL

With special reference to changes in the susceptibility of Sclerotinia homoeocarpa to cadmium and mercury fungicides.

Noel Jackson

Dollar spot disease caused by the fungus Sclerotinia homoeocarpa F. T. Bennett is a widespread and destructive disease of turfgrasses. In Australia, North America and continental Europe the disease occurs commonly on bentgrasses, bermuda grass, fescues, and bluegrasses. In Britain the disease is confined almost entirely to creeping red fescue turf. If left unchecked, infection may result eventually in death of the turf, rendering it unsightly and susceptible to invasion by undesirable weed species.

On turf, the disease is characterized by the development of injured areas that are at first brown, later becoming bleached or straw-colored and up to two inches in diameter. The affected regions frequently coalesce and involve large areas. Infected leaves show yellow-green, water-soaked lesions that progress to a cream or tan color, finally becoming bleached and shrunken; uninfected portions remain green or yellow-green. This banding of the leaves may be made more obvious by the appearance of a definite, narrow, black band which delimits the bleached section of the leaf from the still-green portions. When the fungus is active, a delicate, white, cobweb-like growth of mycelium may be seen suspended between the grass blades in the early morning while dew is present. More abundant production of mycelium may occur naturally with prolonged humid conditions, but mycelial growth can be promoted artificially by covering turf showing symptoms with a sheet of glass or a box. Since dollar spot disease symptoms can simulate other fungal and functional disorders of turf, isolation and identification of the causal organism are often necessary for accurate diagnosis.

From the onset of primary symptoms in a turf area, buildup of dollar spot may be rapid, and once established, it is most persistent. The fungus commences activity in late spring and declines during late autumn, but spots may persist throughout the winter and the disease is resumed on these same sites the following spring. As yet, no sporing or sclerotial stages have been recorded on turfgrasses in nature. It seems most likely that the fungus persists as mycelium or mycelial aggregates in plant debris and this seasonal disease outbreaks occur as a result of favorable conditions for mycelial infection. Transport of infested plant debris on equipment and footwear serves to spread the fungus from the primary infection sites.

Development of the disease is favored by warm (65-75° F.), moist conditions. Usually early summer and early fall are most suitable here in the northern U.S.A. Even in a subnormal rainfall summer the disease will make its appearance, dew and supplemental watering providing sufficient moisture for active growth of the causal fungus.

Potassium and phosphate fertilizer application have little effect on the incidence of dollar spot, and the normal range of soil pH does not appear to influence disease activity of the fungus. However, it is widely accepted in practical turf management that turf grown under adequate nitrogen fertilization with consequent good plant vigor is less susceptible to dollar spot. Though good cultural practices can do much to contain dollar spot disease, elimination of the symptoms calls for preventive fungicidal applications starting in early June, and for the past 20 years fungicides based on cadmium generally have given excellent results. Cadmium-containing formulations have shown a high degree of selective toxic activity against S. homoeocarpa requiring only 0.3 oz. of actual cadmium per 1000 sq. feet on turf at monthly intervals to bring about control of the disease.

During 1964 disease symptoms indicative of dollar spot occurred on Penncross creeping bentgrass turf at the Rhode Island Agricultural Experiment Station. Repeated spray applications of cadmium-containing fungicides failed to control the disease. In the summer of 1965 the symptoms reappeared and isolation from the diseased turf then, and on several occasions during the 1965 season, always yielded a fungus indistinguishable in culture from S. homoeocarpa. Again, applications of cadmium fungicides at the standard rate failed to inhibit the organism, so 3 oz. of a cadmium succinate fungicide, "Cadminate", in 10 gallons of water per 1000 sq. ft. were applied twice at an interval of seven days. Although this was six times the usually recommended rate, the disease was not controlled. The mercury-containing fungicides "Ultra-Clor" and "Kroma-Clor" at 8 oz./1000 sq. ft., Tersan OM (5 oz./1000 sq. ft.), Panogen (3 fl.oz./ 1000 sq. ft.) and Thimer (5 oz./1000 sq. ft.) under a similar spray routine were also ineffective, but Calo-Clor at 2 oz./1000 sq. ft. brought about some reduction. However, one application of Dyrene at the rate of 8 oz. in 10 gallons of water per 1000 sq. ft. effectively killed the active fungus. Further applications of Dyrene at 4 oz. per 1000 sq. ft. at 14-day intervals prevented any recurrence of dollar spot symptoms.

To evaluate further this apparent change in selective toxicity of cadmium and mercury compounds to the fungus, in vitro response tests were undertaken in the laboratory. The isolate from the Penncross turf (R) was compared with an isolate (S) taken from turf consisting of Festuca rubra and having no previous history of fungicide applications. It was presupposed that the latter isolate would not show any tolerance to fungicides. The method chosen for comparing the isolates was the poison—agar plate test. Cadminate (60% cadmium succinate), cadmium chloride, cadmium sulphate, Dyrene and Ultra-Clor were incorporated into potato dextrose agar at the concentrations listed in Table I. Disks bearing mycelium of the two fungi were placed in the center of separate plates in four replicates and the growth in diameter of the resulting colonies was recorded after 3 days' incubation at 25^{o} C. These growth rates were then compared to the growth rate of each isolate growing on potato dextrose agar as control, and the percent inhibition calculated.

Table I. Percentage growth inhibition after 3 days of Sclerotinia homoeocarpa as influenced by fungicides incorporated in PDA media at different concentrations.

	Isolate R Percentage growth inhibition at conc. of:					Isolate S Percentage growth inhibition at conc. of:				
Fungicide	100	50	25	12.5	0 ppm	100	50	25	12.5	0 ppm
"Cadminate"	20.5	14.9	7.4	3.8	0.0	93.3	88.3	84.5	44.7	0.0
Cadmium Chloride*	12.2	8.6	0.0	0.0	0.0	97.3	94.2	84.5	66.1	0.0
Cadmium sulphate*	11.6	6.3	3.3	0.0	0.0	92.3	82.5	81.3	52.9	0.0
"Dyrene" 50 W.P.	91.9	90.8	92.2	84.9	0.0	100.	95.3	91.8	95.8	0.0
"Ultra-Clor"	91.8	38.6	78.9	--	0.0	81.0	68.5	85.3	--	0.0

*Used at Cd. concentrations equivalent to 100, 50, 25 and 12.5 ppm of Cadminate.

The results of the test showed that a considerable difference in response to cadmium salts is exhibited by the two isolates. The fescue isolate (S) showed a graduated suppression of growth as the concentrations of cadmium were increased, little growth occurred above 50 p.p.m. of Cadminate (equal to 15 p.p.m. actual cadmium). Conversely, the Penncross isolate (R) was virtually uninhibited at the concentrations of cadmium used. The same trend was noticed with the mercury fungicide, Ultra-Clor, but Dyrene gave excellent suppression of growth of both isolates, confirming the experience with these materials in the field.

To investigate further the actual concentrations of cadmium and mercury affecting growth of these two isolates, the laboratory invesigation was repeated using madmium chloride and mercuric chloride. The results are presented in Tables II and III.

Table II. Percentage growth inhibition of S. homoeocarpa after 4, 6 and 28 days as influenced by cadmium chloride incorporated in PDA media at different concentrations.

Cadmium chloride (p.p.m. cadmium)	Isolate R			Isolate S		
	Percentage growth inhibition after			Percentage growth inhibition after		
	4	6	28 days	4	6	28 days
0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.5	17.7	0.0	0.0	100.	93.3	10.6
25.0	12.2	0.0	0.0	100.	93.3	19.9
50.0	22.0	9.7	0.0	100.	100.	27.1
100.0	32.2	20.8	0.0	100.	100.	27.3
200.0	38.4	31.0	0.0	100.	100.	100.
500.0	100.0	100.0	86.1	100.	100.	100.

Table III. Percentage growth inhibition of S. homoeocarpa after 4, 6, 8, 10 and 20 days as influenced by mercuric chloride incorporated in PDA media at different concentrations.

Mercuric chloride (p.p.m. mercury)	Isolate R					Isolate S				
	Percentage growth inhibition after days					Percentage growth inhibition after days				
	4	6	8	10	20	4	6	8	10	20
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	78.4	39.3	0.0	0.0	0.0	100.	93.1	83.9	67.2	25.0
15.0	90.2	63.1	24.4	0.0	0.0	100.	100.	100.	100.	100.
20.0	92.8	82.6	58.0	20.5	0.0	100.	100.	100.	100.	100.
25.0	100.	94.3	94.3	94.3	0.0	100.	100.	100.	100.	100.
35.0	100.	100.	94.3	94.3	90.3	100.	100.	100.	100.	100.
50.0	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.
100.0	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.

From the tables it may be seen that isolate R from the Penncross bentgrass was tolerant of much higher concentrations of both cadmium and mercury than the fescue turf isolate (S).

These observations and tests indicate that a race of pathogenic fungus, resistant to the normally effective cadmium and mercury commercial turfgrass fungicides has come about. Reports from South Carolina, Missouri, Indiana and Massachusetts indicate that this change in chemical resistance is not an isolated occurrence and have prompted further investigation at the Experiment Station to determine alternative fungicidal materials.

Tests conducted during the summer of 1966 confirm the effectiveness of Dyrene, 4 oz./1000sq. ft. in 10 gallons. 10-day intervals, as a preventive measure. Good protection was afforded by the following fungicides:

Daconil 2787 @ 4 oz. in 10 gals. water/1000 sq. ft.

Acti-dione - ferrated 1 oz. + 1 oz. in 10 gals. water/1000 sq. ft.

Acti-dione/Thiram @ 4 oz. in 10 gals. water/1000 sq. ft.

CS 5623 @ 4 oz. in 10 gals. water/1000 sq. ft.

UC 23271 @ 2 oz. in 10 gals. water/1000 sq. ft.

Further work is under way to investigate the nature of this resistence to fungicides exhibited by the Penncross isolate (R) and a survey of the variability within S. homoeocarpa is being carried out.

PLANTING COMPOSITION FOR THE GOLF COURSE

L. T. Whitlock

Each year land is consumed at a rapid rate for urban development. Suburbs and communities spring up and with them the need for country clubs and golf courses. As appropriate golf course land becomes scarce and expensive, as construction and labor costs rise, it is significant to note that there is a tendency among new golf courses towards acquiring land that lacks appealing topography, native vegetation and natural hazards. The implications of such tendencies point out the need for adequate design considerations in creating an interesting and challenging course of play as well as an appealing environment. These design considerations become especially important since the golf course should offer a relief from the community and suburban mode of life. This splash of green within the jungle of buildings, traffic-jammed streets, parkless subdivisions, and people-packed homes is a virtual oasis in man's well being. The success physically and economically of a golf course is then determined by the degree of amenities offered to attract the individual.

Too often the term "landscaping" has had the connotation of merely ornamentation upon the golf course, the home, and the community. On the golf course it is often thought of as the process of making the course prettier (or the actual implementation of planting trees and shrubs). Too seldom is "landscaping" thought of in terms of the design potential that plant materials offer as an aid in achieving a functional, beautiful, and challenging course of play. The landscape architect is trained to evaluate the existing conditions, to investigate desired functions and required aesthetics, integrating all these into a unified design in which each individual using the facilities will profit in an emotional, as well as a physical experience.

This coordination of factors is much more complex than one would imagine and is usually thought of only when the end result is not the success initially pictured. The scope of factors causing such failure is immense. They include soils, drainage conditions, microclimate, a lack of coordination between land features, physical course layout, and improper selection of plant material. Poor or improper maintenance must also be included in this list.

The primary factor in judging the success of a golf course is its <u>environment</u>. Environment as Webster defines it, "is the aggregate of all conditions and influences affecting the life of an organism." This organism in our case is man. This means that the golfer is influenced by various physical designs of golf course play such as: the actual form of the fairway, placement of traps and hazards, directional indications of play, the break of a green, the size and organization of tees or the sequence of shots. Plant materials should complement and accent these factors. Through proper design, plants can reinforce the functioning feature of the course such as: the protection of players by proper selection and placement of trees and shrubs, the channeling and speeding up in movement of players in desired directions through the use of paths and plant materials and the incorporating of plants for the screening off of undesirable elements. It is obvious that a certain amount of overlap occurs between the design forms of challenging play and the functioning forms of protection and efficient movement through the course. Coordination between these factors is essential and further coordination in reference to aesthetics gives the key to overall success. The designer is concerned with aesthetics, so that when you play the course you experience certain sensations, emotions and appreciations arising from the proper use of plants. Examples of this element on the golf course varies from patterns of shade and shadow upon the fairways and greens to the peace and tranquility associated with large open spaces.

In the successful use of plant materials, a chief concern for golf course personnel is to become aware of the actual existing conditions and the visual scene that should be created. One must study the golf course in its entirety, each sequence of play and of individual fairways. But even more important to the greenskeeper, is for him to develop his own source of awareness. This is the basis for thoughtful analysis. Where, when, and how do individual plants and plantings fit into the overall scheme? What, besides a good score makes the player feel satisfied and content as a result of his hours on the course? Will he be anxious to return to a specific course? It is to satisfy this emotional and psychological need that you must continually search for the potentials available.

Upon analysis, we find that the successful golf course is made up of many facets, but let us take a single basic design consideration with which we are more familiar. Let us consider the factor of "scale" and apply it specifically to trees. "Scale" for our purposes means that a man in a given space feels so big or so small. His ability to fit into and feel comfortable in any situation varies with his own size or stature in relation to the size or scale of the space of which he is a part. The size or scale of the surrounding plant material acts as a strong factor in the scale of the space, and thus is of direct important in our comfort and ability to feel at ease. A single man standing alone on a football field will not feel as much at ease as if he were in his back yard. The lone man stands out on the football field as a foreign element; but, if a group of people are on the field, the foreignness is not acute. Man relates the landscape into terms of his own understanding and his own size. Therefore, the man, as one of many, on a football field is more at ease in that he relates himself to others or elements of a similar size and nature. On the golf course we create many spaces, but always we want to relate man to them in terms of his relationship to "scale." This is utilizing design potential. For instance, just as man relates the landscape into terms of his own understanding, we see that a singular tree on a flat plain stands out sharply and becomes a point of emphasis. This singular tree, just as the single man on the football field, relates poorly in scale to its surroundings. But, in terms of design, perhaps this point of emphasis is needed. We can see how a single tree, different in character or color from adjacent material may serve as a distance marker or guide to the green; we can see why several evergreens used singularly induces spottiness into the course. This becomes evident because we see how the factor of "scale" relates to man and plant materials!

In summing up, it should be remembered that we begin with the basic knowledge of fundamentals in composition and apply these with the limitations, site potentials, physical layout, and plant materials to gain a successful design.

WEED CONTROL IN TURF

J. D. Butler and H. J. Hopen

There have probably been more advances made in weed control than in any other phase of turf management. Most weeds can be easily, and often inexpensively controlled. In fact, in making a recommendation for crabgrass control on established bluegrass, one can feel safe in advising a person to "go to a supplier and get a preemergence material; if used properly it should do the job." Likewise, some rather general recommendations can be made for most broadleaf weeds; however, here the weed species may need to be given special consideration. Today the big weed problems are due to perennial grasses. As successful selective control of these perennials appears some distance in the future, it is necessary to consider physical and chemical control with whatever is available.

Physical Control

Methods of physical control are seldom considered, as the labor and expense involved are often prohibitive. In many instances, however, such practices as stripping off the sod or tilling small areas may give better results and require even less time than chemical control.

Non-Selective Herbicides

There are currently 3 common non-selective materials being used in the turfgrass industry. These chemicals have several uses such as the destruction of existing vegetation before establishment of turf, weed control in parking areas and gravel paths, and to edge along walks and fences, etc. If a non-selective material is to be used for spot weed control, the question arises whether or not it is better to have undesirable grasses in the lawn, or be willing to tolerate unsightly patches -- often for some time -- before a uniform turf can again be developed.

Dalapon (2, 2-Dichloropropionic acid) is an effective grass killer. This material is absorbed through the foliage and roots and is readily translocated. As translocation is materially reduced by contact injury, 2 or 3 applications at moderate levels would be expected to give better control than a heavy application. If grass is mature, control may be rather poor. The rate of absorption is dependent upon the amount applied, humidity, temperature, kind of plant, etc. Dalapon absorption is most rapid during the first few hours after application, but may continue for 2 or 3 days. Wax impregnated bars are available, but the material is usually applied as a spray. Dalapon is hygroscopic and may undergo chemical change upon absorption of water. For spot treatment, use 1 pound of Dowpon (dalapon) in 3 gallons of water. Spray to wet foliage. From 4-6 weeks should lapse from time of treatment to reseeding.

Cacodylic Acid (dimethyl arsinic acid) has contact post-emergence herbicidal activity. This relatively safe material has a short residual in the soil, and reseeding can be done a few days after treatment. This chemical is hygroscopic and should be stored in an airtight container. Cacodylic acid has immediate contact activity. Rain 3-4 hours after application should not affect its herbicidal activity. Cacodylic acid may be applied either as a spray or in dry form. Follow label directions when applying this material.

Paraquat (1, 1' -dimethyl-4, 4' bipyridinium bis (methyl sulfate) is a nonselective contact herbicide. It is widely used as an aquatic herbicide. The big advantage of paraquat would seem to be the fact that it is absorbed on the soil particles rapidly, and apparently leaves no residue. This allows for immediate seeding or sodding. This material is quick acting on both broadleaf and grass plants. A moderately toxic chemical, paraquat, is registered for non-agriculture crop areas but is not now approved for sale or use by homeowners. Paraquat is recommended for use at the rate of ½ pound active ingredient per acre. For grass control a non-ionic surfactant is suggested.

Control of Specific Perennial Grasses

If a few of the perennial grasses are reviewed in light of the foregoing discussion, we can better understand the problems that we face, as well as possibly derive some current satisfactory methods for controlling the serious weeds.

Nimblewill

This grass is a serious weed on many well-maintained golf courses and a common weed problem for homeowners. Nimblewill is a heavy seed producer when maintained at 2 inches, and is able to become established in a dense turf, perhaps through the production of toxins or in some other fashion. The chemical control situation for this weed is the same that appeared in the 1960 Illinois Turf Conference Proceedings. Liquid Zytron and Endothal applied as post-emergence sprays have some possibilities for control. Although the results have been variable, they offer a possibility. New chemicals and formulations have been tried, but they have not proven successful. On small patches it has been felt best to suggest complete removal of the nimblewill either with a sod cutter or shovel, then replacement with sod, because re-infestation of the bare areas is likely to result from nimblewill seed if seeding grass is relied upon to get re-establishment. Of course the non-selective herbicides suggested above might be used, but these materials would not take care of the nimblewill seed problem.

Bentgrass

Various amounts of success have been reported with hormone-type herbicides (2,4-D, silvex, etc.) for the control of bent, but our results with these materials have been disappointing. Our general recommendations have been complete removal of the bent with a sod cutter or shovel, then re-establishment--preferably with sod, or perhaps by seeding. The fact that the bent propagates itself from stolons that may be left is a necessary consideration. The redtop weed problem, which from the number of samples received this year is becoming increasingly serious, can be handled much like bent, although it seldom occurs in individual clumps. Although the contact herbicides may give an apparent kill, the bent stolons may remain viable and green up after a few weeks.

Tall Fescue

Tall fescue continues to be one of the most serious weed problems. The usual suggested control for tall fescue is to dig out the individual clumps, and then reseed or resod the area. If the clumps are small, of course the surrounding bluegrass will fill in the holes in rather short order. It is only necessary to dig about 1 inch deep to eradicate this weed. However, be sure to get all the side shoots. A non-selective chemical such as dalapon can be used for spot treatment, usually with a rather high degree of success.

Quack, Bermuda, and Zoysia

These grasses, because of deep rhizomes, are not easily controlled by lifting the sod unless it is cut especially deep. Various materials and methods have been suggested for control, but many of these suggestions have produced eratic results. Repeated use of materials such as dalapon may be necessary to do the control job. Fumigants such as methyl bromide have been very effective in contolling these grasses. Another possible method for control of these weeds would be removal of the sod, and chemical treatment of the grass after re-growth starts.

Poa Annua

There are many gaps in the total picture of this grass that need to be filled so that better control methods can be worked out. There are a few good indications that this grass is a perennial. On this basis, and because of its importance it will be considered here. There are two drawbacks to using the contact materials on this weed: (1) this weed is common in bent, especially on greens where the surface cannot be marred, (2) reproduction from large amounts of seed in the soil. Since Poa annua seldom occurs in patches that can be stripped, this physical control is usually ruled out. We are currently testing several herbicides for Poa annua control. There is one criteria that must be met by these materials and that is that bent should have a rather high tolerance for them. Of the materials that we have under test to date, Betasan is doing the best job, and has the desired safety for use on bent.

Summary

With the rapid advances made in the herbicide field there are still major problems. The need of controlling one perennial grass in another perennial (blue-grass, bent, etc.) is currently the number one turf weed problem. Although there are chemicals available that are used on these weeds, these mostly have little selectivity. Something that would give the control that we can now get on crabgrass on Poa annua, tall fescue, etc. would be welcome indeed.

SITE SELECTION FOR GOLF COURSES

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Site selection for a golf course today is not quite the same as it used to be. Prior to World War II, property in close proximity to metropolitan areas was reasonably available. Today, this is not the case. It is difficult within a reasonable price range to locate sufficient acreage necessary to build a golf course. Where such tracts of land can be located, often they are not suitable. However, if the need or desire is sufficiently great and funds are available, a golf course can be built anywhere in the world, including the middle of the Atlantic Ocean or the top of the Teton Mountain range in Wyoming, though turf cover may not always be the best. Even so, there are a number of things which must or should be considered when obtaining a piece of property for use as a golf course:

I. Agronomic

Without question, a sandy soil with good internal drainage is superior for culture of golf course turf if adequate amounts of water and plant nutrients are made available. The percent of clay and silt, but especially silt, contained in a sandy soil must be relatively small or internal drainage is materially impeded, especially after such a soil has been compacted. The most suitable sand should contain no more than a total of 10 to 15 per cent silt and clay (less is satisfactory). But as previously stated, adequate amounts of water and plant nutrients must be made available.

Golf courses on sandy soil are in play early in the spring and playable later in the fall, as well as affording only minor interference to play following heavy rains. Grasses root deeper, soil does not become "dangerously" compacted, anaerobic conditions do not develop, thus turf diseases are less of a problem. One often hears the comment it is much easier to apply water when needed than to remove excess water. The main draw-back in working with this type of soil is that turf is difficult to establish and a soil this sandy is tough on "treaded" machinery.

A soil high in clay content is superior to a soil high in silt content. However, the difference is not of significant consideration as artificial compaction will cause both soils to behave quite similarly. If you expect to grow good turf, silt-clay soils require that special emphasis be placed on surface drainage. If terrain is flat (or for any other reason) every effort must be made to develop swales so that surface drainage is assured. Even so, usually this is not adequate and extensive tile must be installed. Further, we are finding that simple installation of tile is not adequate as water will not enter tiles with sufficient rapidity. Risers or vertical outlets running from tile to soil surface are placed so that surface water immediately reaches tile. Slit trenches filled to the surface of the soil with gravel placed as needed further facilitate tile drainage. If surface drainage is not assured, it is a foregone conclusion that water-holding areas will either "scald-out" or grass will succumb to the ravages of various fungi during the hotter periods of the year.

Peat areas should be avoided. Even though turf will grow vigorously on peat, it can not be trusted. Heaving during the spring of the year is a serious problem and one which is almost impossible to overcome. Nonetheless, and as said before, if real estate is at a premium, a golf course can be built on peaty areas even though future problems will be numerous. Installation of sub-surface drain tile is a necessity if peat areas are relatively large. Clay, silt and peat soils do not leach readily. Therefore, plant nutrients are more tenaciously held, as well as water. Thus, costs for water and fertilizer will be reduced over those for a sandy soil.

Gravel deposits are satisfactory if such gravel is covered with at least 4 inches of suitable loam. This can be expensive. If a choice can be made, by all means select the site which contains a soil with the highest percent of sand.

In the midwest part of the country, excess acidity or alkalinity are not of paramount consideration. Nonetheless, occasionally lime must be applied, but especially on soils of a sandy nature. In any event, this problem is of relatively minor concern but one which must be corrected when encountered.

II. Terrain

Here again, a golf course can be built on practically any type of terrain if the demand is great enough and sufficient money is available. But, there are certain terrain types or features most suitable. Gently rolling topography with one or two creeks running through which lends to the development of water holes or lakes, is the most suitable. Completely flat land can present quite a problem, especially from the expense angle. A compitent architect wishes to design such areas so that rolling features or articial mounds, etc., are included in the finished product. If so constructed, the expense of building increases. Naturally, if a flat, un-interesting lay-out is all that is desired, this is the least expensive terrain with which to deal.

Property of a rolling nature which does not contain severe hills is available in most areas of the midwest. Mountainous sections have a greater problem. Here, terrain should be located so that valleys are sufficiently wide to contain at least one hole, if there is reasonable access to an adjoining valley or flat piece of property. By easily accessable it is meant that at no time should a golfer expect to traverse steep hills. On any hole, the rise should not be greater than 100 feet. If it is impossible to locate terrain where this 100 foot factor can not be contained, greens should be located half-way up relatively steep hills with the following tee located on top of the hill (or where desired). With such an arrangement,players have the opportunity to putt-out on the mid-elevated green, thus breaking the climb. A better arrangement yet is to locate valleys whereby two holes can be placed or play is up the valley on one hole and back the following hole. Every effort should be made to locate steepest climbs on beginning holes. This will avoid, especially for older golfers, traversing steep hills during later holes. With modernday construction equipment, it has become possible to flatten out many areas or make swales through hills so that hilly terrain has become somewhat less of a deterrent.

Potential soil erosion must be avoided. Creeks or rivers which run through the proposed site should be checked closely for this problem. Further, areas which flood regularly are definitely out of consideration if flooding can not be controlled. I have yet to see an area which regularly floods where good, usable turf has been maintained. With gentle flowing, winding creeks where flooding is not a serious problem, water holes and lakes can be economically developed.

III. Trees

Trees are of a very definite consideration when it comes to considering a piece of property for a golf course. It is expensive to clear a dense woods. However, the expense may not be much greater than that of planting trees and foresting a bare area, usually after play has commenced. If other factors were relatively equal, advantages would be gained by selecting the side which contains the greatest number of usable and suitable trees.

IV. Rocks

Obviously, rock out-croppings or presence of rocks of any size greatly increases the cost of building. This does not mean that a reasonably good golf course can not be built on a rocky site, but increased cost must be considered. As well as removing rocks, it may be necessary to transport considerably more top-soil than normal. If possible, terrain which contains rock out-croppings or surface rocks should be avoided.

V. Location, Shape and Size

The shape of the parcel of ground is of some consideration. A long, relatively narrow configuration is not good because it is difficult to design 18 interesting golf holes. Also, it is rather difficult to design 18 interesting holes on a completely square piece of property. Of importance here is to locate a piece of property whereby 18 interesting holes can be developed with the 1 and 10 tees and 9 and 18 greens located in close proximity to where the clubhouse is to be built.

Intensive consideration must be given to the location of the clubhouse. This includes parking facilities, availability of 3 phase electricity, nearness of access roads and water supply. Also, the clubhouse should be located "aesthetically".

An area of 160 acres is considered barely adequate by many of the better golf course architects. Most prefer to have in excess of 200 acres in which to operate. However, it must be remembered that many golf courses are placed on less than 120 acres. For the selection of a new site, an area of at least 160 acres minimum, preferably 200 acres, is suggested.

VI. Supply of Water

Anyone selecting a site for a new golf course at the present time must consider the installation of a fairway watering system. If it is not to be installed immediately, eventually it will be. Therefore, the all-important consideration of a water supply. If you happen to be in an area where underground supply is not adequate, either a municipal or a surface supply must be assured. The surface supply would mean that the golf course should be located on a creek or river so that reservoirs can be developed. In any event, a supply of at least 1500 gallons per minute in the midwest part of the country should be considered for the entire operation, including the clubhouse. Naturally, water must be what is known as "sweet", which means it does not contain excess amounts of soluable salts or impurities.

VII. Cost

The price of real estate has reached astronomical figures, especially in close proximity to large metropolitan areas. This would mean in many instances, people interested in purchasing property for a golf course must either go further from the metropolitan area or perhaps obtain a piece of property which would not be considered the most suitable for development of a golf course or pay an exhorbitant price. This must be taken into consideration by those interested in purchasing the property. It would be to their advantage to consult with someone who is familiar with these problems such as a field representative of the National Golf Foundation.

Obviously, the type of terrain selected will have the greatest bearing on the construction cost. Natural rolling terrain as discussed above is the most suitable as well as being the least expensive to develop. Variations for this or the presence of bogs, hills, gravely or marsh areas increase the cost of construction considerably, depending upon the amount of "poor" terrain. Also, as previously mentioned, it can be more expensive to build an interesting golf course on flat terrain if indeed an interesting golf course is to be constructed. But, if just a general flat lay-out is to be developed, level terrain offers the least resistance.

The type of soil and terrain are main features when considering maintenance costs after completion. Steep, hilly terrain or areas which tend to flood are the most expensive to maintain. Obviously, the flatter the property, the cheaper it will be to maintain unless said flat areas contain large peat deposits and surface drainage has not been assured. Even though sandy soils require excess quantities of plant nutrients and water, overall maintenance will not be greater as other factors come into play. Extensive sub-surface drain arrangements usually are not necessary with sand. Expensive aerotilling, aerification and overseeding operations usually are not as necessary or as frequent, fewer fungicides need be applied, or you might say that when turf is generally healthy, it is less expensive and less of a problem to keep.

VIII. Accessability

In this regard, the most important consideration is the accessability of the considered piece of property to golfers. Or, is the golf course located in such an area that either daily fee players or members are available. This used to be of even greater consideration before super highways became a reality. Many country club members maintain an active membership at a club even though they live in excess of 50 miles away. Also, daily fee golfers will travel many miles to play a golf course which they particularly like. Invariably, one will find the daily fee players travel to golf courses which have a reputation of "good grass" and an interesting lay-out. These "good grass" and interesting lay-out courses are normally built on sandy, well-drained soils and have a rolling terrain, as well as a reputation for maintaining good putting conditions at all times. Nonetheless, it is far better to locate as near as possible to the golfing product.

Availability of golf course workers is becoming a rapidly increasing problem. Golf courses located in industrialized areas are finding it extremely difficult to obtain competent workers because of wage competition. Availabilities of caddies is becoming less of a problem as mechanized carts find a greater use on daily fee golf courses and private country clubs.

IX. Trend of the Area

Is the area going commercial, industrial or residential?

Industrial and commercial areas do not lend themselves well, especially to private country clubs. There may be a different story for daily fee operations as a supply of golfers is readily at hand. Private country clubs should consider development in a residential area, especially one in close proximity to its members. Indeed, there is a trend for private country clubs to "sell out" if surrounding location has become industrial or commercial and rebuild in residential or indeed farm areas. In any event, for the selection of a golf course site for the development of a new golf course, one is almost forced into out-lying areas because of property costs.

X. Conclusion

The selection of a golf course site is of paramount importance especially from the construction, establishment and eventual turf maintenance standpoint. Nonetheless, property has become of such excessive value that inferior sites frequently must be obtained and worked. If so, it is necessary to obtain competent assistance before proceeding.

KENTUCKY BLUEGRASS TODAY

J. D. Butler

Bluegrass is the turfgrass of the Northern Humid Regions of the U. S. Although there are perhaps some 400 species of bluegrass, only one of these species, Kentucky bluegrass (Poa pratensis L.), is important as a lawn grass.

Everyone in the industry has visualized an ideal turfgrass. By combining the outstanding characteristics of certain of the Kentucky bluegrasses available today, a near ideal type would evolve. Diseases certainly must be one of the most important limiting factors in turf production. A high degree of resistance to certain diseases is now available in individual varieties, such as Merion's resistance to Helmintosporium leafspot, Newport's resistance to rust, and Anhauser Dwarf's resistance to powdery mildew. If these resistances could be combined into one variety then our ideal grass would be much closer to reality.

Kentucky Bluegrass Varieties

Today there are approximately 12 varieties of Kentucky bluegrass available. These varieties arise from individual or group selections that usually have exhibited one or more outstanding characteristics. After having been collected, the potential varieties are usually released for testing -- preferably at several different locations and under several different maintenance programs. Information gathered from testing is then assimilated for evaluation of the variety. The decision on whether or not to release a grass must be made by one or more people. Release does not always guarantee that a variety is outstanding since it may be generally inferior to existing Kentucky bluegrasses. However, since Kentucky bluegrasses are generally superior to most other grasses, the single fact that the grass is a Kentucky bluegrass is in its favor.

As there is little visible difference between the Kentucky bluegrasses management practices, season of the year, etc., can materially <u>effect</u> the appearance of the grass. In the fall, and under good management, Newport may resemble Merion, and when common Kentucky is well fertilized and watered it can look much like Merion. In fact, poorly maintained Merion will usually not look as well as common Kentucky receiving similar or better care.

Below is a summary of pertinent information on the different available Kentucky bluegrasses. This information has been gathered from various publications plus personal experience with these grasses. Grass Varieties in the United States, Agriculture Handbook No. 170 authored by A. A. Hanson was an especially valuable source of information.

<u>Common Kentucky or Kentucky</u> - This grass, which is native to Europe, is a composite of many different types. Common Kentucky bluegrass is not considered a variety. Under competition, when seeded at relatively high rates, a general uniformity will usually prevail although patches of "off types" may occur. Under most situations the texture will be intermediate between Merion and Prato. The color is a medium green. The most serious drawback is probably the susceptibility to Helminthosporium leaf spot. Seed is readily available, but may be imported or a named variety of Kentucky. The following varieties are selections made from Kentucky bluegrass.

Merion - This selection was made on the Merion Golf Club in Pennsylvania in 1936 and released in 1947. This dark green, low growing grass forms a dense turf that will stand close mowing. Establishment of Merion from seed is rather slow, although after a few years Merion frequently predominates when included in a Kentucky bluegrass mixture. Merion has a high resistance to Helminthosporium leaf spot, but is quite susceptible to rust and powdery mildew. It is recommended only for areas north of St. Louis, but has been outstanding in tests at the Dixon Springs Experiment Station near Paducah, Kentucky. Merion has highly apomictic reproduction. The seed is readily available although much in demand.

Delta - This bluegrass is a single plant selection released by the Canada Department of Agriculture in 1938. This rather vigorous grass has an erect growth habit. Established Delta is quite similar to common Kentucky both in color and texture. Delta is quite susceptible to Helminthosporium leaf spot although it will reportedly recover more rapidly from this disease than common. A marked resistance to mildew has been reported. The incidence of stem rust is similar to common. Delta has highly apomictic reproduction. Seed of Delta is readily available.

Park - This vigorous grass is a "synthetic variety" of 12 or the best apomictic strains collected by personnel of the Minnesota Agricultural Experiment Station in 1937 and released in 1957. Texture of established Park is similar to common Kentucky, but may have a slightly darker green color. Park is susceptible to Helminthosporium leaf spot, but has a relatively high resistance to rust. Germi-nation occurs a day or so earlier than common. Space plantings have generally produced plants of rather similar type. This grass is grown widely in the northern U.S.. Seed of Park is available in quantity.

Newport - This grass was collected from the coastal bluffs at Newport, Oregon. After testing Newport was released in 1958. This vigorous grass has a wide, dark green foliage. Its appearance is especially good in the fall, probably partially due to a relatively high resistance to rust. Newport reportedly has some resistance to Helminthosporium leaf spot. Newport has apomictic reproduction. This grass is a good seed producer and seed is readily available.

Prato - This introduction came out of Holland. Prato comes from 3 plants that proved superior in density, texture, and tolerance to Helminthosporium vagans, and dry soil conditions. Prato produces a dense turf with narrow leaves and with older leaves that end to be prostrate. Prato is lighter green than common. Prato is reportedly moderately resistant to Helminthosporium spp., and at least moderately susceptible to rust. Seed is available from Northrup, King and Co.

Windsor - This recently introduced variety was collected in 1949 from a grazed pasture in Ohio. Information on this grass is still quite limited. Windsor produces a dark green, dense, vigorous turf that is somewhat finer textured than Merion. Leaves of this grass tend to be more prostrate than common, Delta, and Park. Windsor reportedly has a high resistance to Helminthosporium leaf spot and rust. Windsor has facultative apomictic reproduction. The original Windsor clone was patented in 1963; patent protection does not apply to seed. Seed available from O. M. Scotts & Sons Co.

Arboretum - This southern variety originated by collecting seed from a bluegrass stand at the Missouri Botanical Garden Arboretum near Gray Summit, Missouri. Arboretum was released informally. Its appearance and other habits are quite similar to common Kentucky. Its performance at the Dixon Springs Station has been similar to Delta and Park, but somewhat better than common.

A-10, A-20, and A-34 - These grasses were selected by and are available from Warren's Sod Nurseries, Palos Park, Illinois. A-10 is a dark green, relatively fine textured grass that appears to be well adapted to southern regions. At the Dixon Springs Station A-10 has been outstanding. A-10 has been patented. A-20 is lighter green than A-10 with a texture similar to common. Considered its most promising features are its resistance to stripe smut, leafspot, and powdery mildew. A-34 was selected because of its shade tolerance. A-34 has a rather broad, light green colored leaf and it forms a dense turf. This grass has been widely under shade conditions in the Chicago area. A-34 will apparently tolerate up to 65% shade.

Today there are several selections undergoing testing that seem to be doing very well, although they have not been released. Belturf, from the USDA at Beltsville, Maryland has proven outstanding in our tests. K5(47) from Pennsylvania is another promising selection now undergoing testing.

Mixtures of Kentucky Bluegrass

Mixtures of the released Kentucky bluegrasses often appear on the seed and sod market. The mixtures are recommended in order to capitalize on the various assets of individual varieties. Management practices and ecological factors will in time probably allow for domination of one of the bluegrasses. Pure stands from individual varieties, like mixtures, have favorable attributes such as uniformity, better resistance to a specific disease than a mixture, etc.

Kentucky Bluegrass Outlook

The outlook for development of grasses that may fulfill individual ideals has certainly improved during the last few years. With the increased emphasis put on turfgrass by institutions, firms, etc., more and more financial support has gone and will go into turfgrass breeding programs. Vegetative propagation will probably be increased. Better methods and equipment and more personnel involved in testing will allow for introduction of only the outstanding new varieties.

Although the future seems bright for development of some new and outstanding bluegrasses, there are already many that will make an excellent turf. The development of our present-day grasses has generally required several years' work by many people. Current and future grasses will undoubtedly change the concept of the ideal grass. Thus today, and in the future, the decision of which bluegrass(es) to plant must be approached on an individual basis, by considering those that are available.

THE EFFECT OF CERTAIN MANAGEMENT PRACTICES ON THE BOTANICAL COMPOSITION AND WINTER INJURY TO TURF CONTAINING A MIXTURE OF KENTUCKY BLUEGRASS (PAO PRATENSIS,L.) AND TALL FESCUE (FESTUCA ARUNDINACEA, SCHREB.)

Robert W. Miller*

The experience with a mixture of tall fescue and Kentucky bluegrass on the bootball field of the Ohio State University Stadium stimulated the research project on which I will report. The Ohio State University Athletic Department in 1961, decided that a renovation program was necessary for its football field. At that time the turf consisted of a poor common Kentucky bluegrass sod which was heavily infested with bentgrass, yellow nutsedge, and various other obnoxious weeds. It was decided that a complete renovation program was necessary.

After the last game of the 1961 season, the existing sod was removed with a sod cutter. This was followed by the establishment of a new set of drainage lines over the field. A soil was constructed, graded to the proper contour, and fumigated to destroy weeds and weed seed.

In early April of 1962 the field was seeded to 90 percent tall fescue and 10 percent Kentucky bluegrass by approximate seed count. The actual seeding rate was nine pounds of tall fescue and one-fourth pound of Kentucky bluegrass mixture per 1000 square feet. The Kentucky bluegrass consisted of a mixture of Delta, Newport, and Merion.

Good sod cover was present by June 8. During the first playing season tall fescue dominated the turf. Careful analysis indicated 80 to 90 percent was tall fescue. Tall fescue was seeded previous to each football game and cleated in by the players. Less than 25 percent of the turf was tall fescue during the 1963 season. By the 1964 season almost all the turf was Kentucky bluegrass. Today there is no tall fescue in the turf except for isolated plants around the edge of the track which surrounds the field.

It was evident by the end of the 1963 season that tall fescue would not last on the football field. In 1962 a study had been established to evaluate management practices for tall fescue - Kentucky bluegrass turf. This study was modified in an attempt to determine why the tall fescue was eliminated from the turf on the football field.

The study included five grasses or grass mixtures. Merion, Delta, Newport and a mixture of the three varieties were each seeded with tall fescue. Tall fescue alone made the fifth treatment. Seeding rates were the same as for the football field. Other variables included in the study were three fertility levels, two mowing heights, and supplementary water and no supplementary water. During the 1962 and 1963 season the fertility variable consisted of nitrogen levels of 0, 2, and 4 pounds per 1000 square feet. In 1964 nitrogen rates were changed to 0, 4, and 8 pounds to represent a wider nitrogen variation. All plots received equal applications of phosphorus and potassium. At establishment, the entire experimental area received fertilizer, including nitrogen, according to soil test recommendations.

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The mowing variable was a 2 and 3 inch height of cut with a rotary mower. Plots receiving supplementary water were irrigated about 24 hours after the plants began to show stress. No supplementary water was needed in 1965 and 1966, because of abundant rainfall during normal critical periods. Differences between irrigated and non-irrigated plots were inconclusive and will not be discussed in this paper.

Effect of Nitrogen Level on Grass Composition

There were no clear cut differences among the nitrogen levels in the amount of bluegrass or tall fescue in the turf during the first growing season. It was believed that residual nitrogen from the application at establishment was sufficient to mask differences that might have occurred.

By 1963, the second growing season, differences among nitrogen levels in the amount of tall fescue and bluegrass present in the turf were evident. Plots treated with either the 2 or 4 pound rate of nitrogen contained more bluegrass and less tall fescue than plots receiving no nitrogen. No differences existed, however, between the 2 and the 4 pound rates.

The amount of Kentucky bluegrass present in the turf was small in 1962 and 1963. In 1963, plots receiving 0, 2, and 4 pounds of nitrogen per 1000 square feet contained 0.73, 1.41, and 1.76 percent bluegrass respectively. The tall fescue component made up the remaining precentage except for an insignificant weed content.

In October of this year (1966) a critical examination was made of the amount of Kentucky bluegrass and tall fescue present by taking a core with a golf cup cutter and counting the shoots of each species. Remember that the nitrogen rates were altered in 1964. The 0 rate remained the same, the 2 became 4, and the 4 was changed to 8 pounds per 1000 square feet.

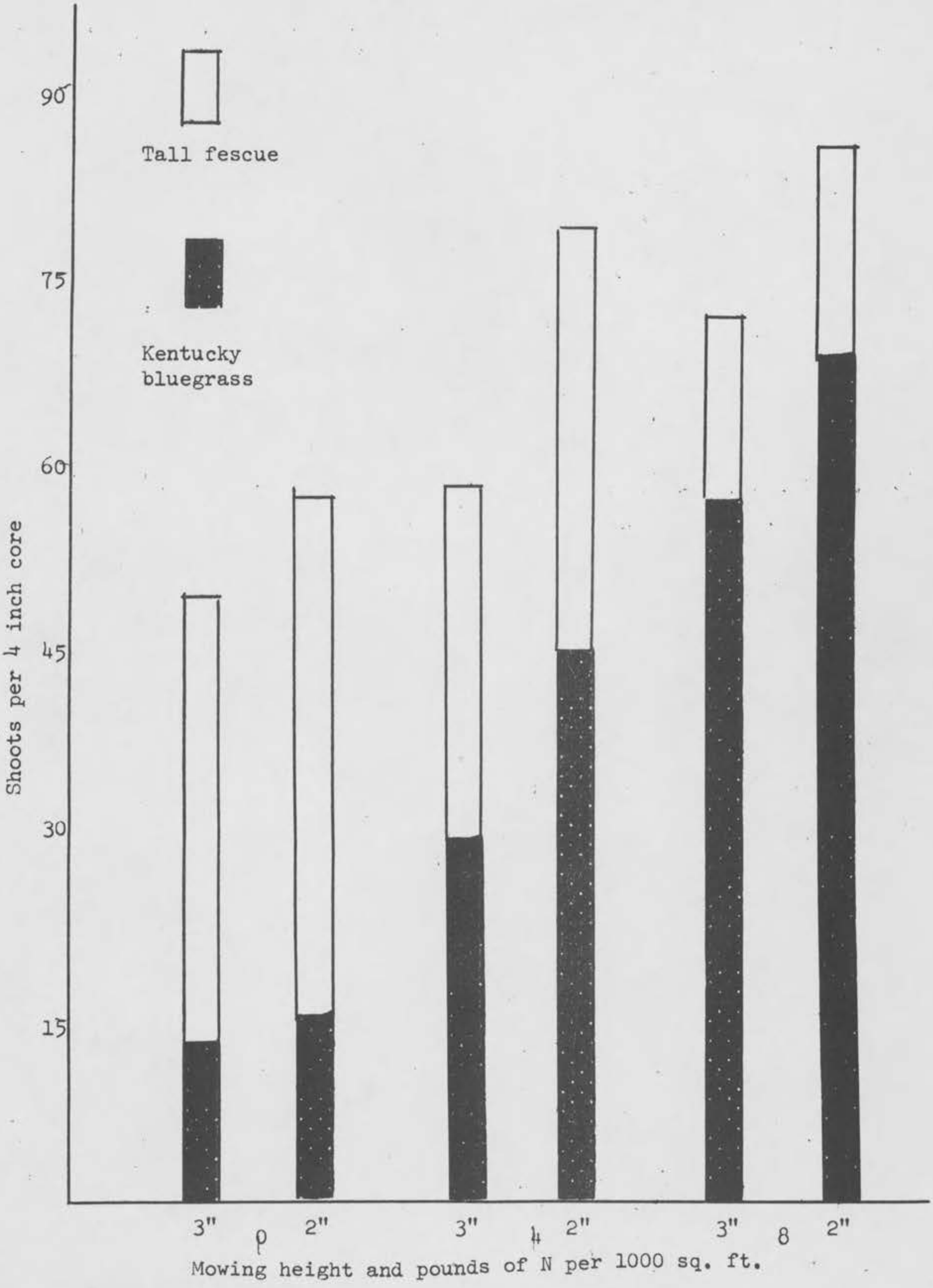
The bluegrass percentage greatly increased in all plots. Even though plots that had received no nitrogen since establishment in the Autumn of 1961 appeared to be mostly tall fescue, bud counts revealed 24 percent bluegrass in 1966. It should be pointed out that a shoot of bluegrass does not cover as much as a shoot of tall fescue. Therefore, less than 24 percent of the ground was covered by bluegrass in these plots.

Plots which received 4 pounds of nitrogen per 1000 square feet since 1964 contained 52 percent bluegrass by bud count and plots which had received 8 pounds contained 80 percent. Figure 1 summarizes the relationships between nitrogen fertility, mowing height, and bluegrass and tall fescue composition of the turf. Note that as nitrogen fertility was increased the bluegrass portion of the sod increased as the tall fescue component decreased.

Effect of Seeding Mixture on Grass Composition

During the first growing season the bluegrass component of plots containing Delta Kentucky bluegrass was greater than plots containing Merion, Newport, or a mixture of the three bluegrass varieties. The fact that Delta germinates quicker than most bluegrass varieties may explain the initial advantage for that variety. By the second year the advantage had dissipated.

Figure 1. The effect of nitrogen and mowing height on the total number of shoots in a mixture of tall fescue-Kentucky bluegrass turf. Counts made October 1966.



In October 1966, the only difference among the bluegrass varieties in the number of bluegrass shoots per unit area was a reduction in shoots of Newport compared to other varieties. As expected Newport plots, which contained less bluegrass, also had more tall fescue than plots containing other bluegrass varieties (Table 1).

Table 1. The effect of seeding mixture on the number of tall fescue and Kentucky bluegrass shoots. Counts made October 1966.

	Seeding Mixture			
Grass	Tall fescue-Merion	Tall fescue-Delta	Tall fescue-Newport	Tall fescue-Merion, Delta, Newport
Kentucky bluegrass	40	38	32	40
Tall fescue	30	26	35	29
Total	70	64	67	69
	(Shoots per 4 inch core)			

Effect of Mowing Height on Grass Composition

The number of shoots of Kentucky bluegrass and tall fescue increased as the mowing height was decreased from 3 to 2 inches. The increase was greater if either 4 or 8 pounds of nitrogen were applied than if no nitrogen was used. Although a small increase in shoot number occurred if no nitrogen was applied and if the mowing height was reduced from 3 to 2 inches, the difference was not significant. Table 2 illustrates the effect of mowing height.

Table 2. The effect of mowing height on the number of tall fescue and Kentucky bluegrass shoots. Counts made October 1966.

	Number of shoots	
Mowing height	Tall fescue	Kentucky bluegrass
2 inches	31	42
3 inches	28	33
Average	30	38
	(Shoots per 4 inch core)	

Relationship between Management Factors and Winter Injury

Why did Kentucky bluegrass increase and tall fescue decrease? Could it be because Kentucky bluegrass was more competitive? Observation led us to believe that tall fescue was more susceptible to winter injury than Kentucky bluegrass. The differential effect also appeared to be greater under the management regime consisting of lower mowing and higher nitrogen fertilization.

To examine some of the management and temperature factors which affect the winter injury of turfgrasses, a two-year study was initiated. Four-inch cores were taken from plots containing Merion bluegrass. Before sampling, the plants were allowed to harden naturally in the field.

The samples were placed in a Sherer-Gillett low temperature growth chamber. The photoperiod, controlled by a timer, was set at 10 hours light and 14 hours darkness. Four cold treatments were used in the 1964-65 study and were as follows:

Cold treatment A - 30 days at 10° Fahrenheit

B - treatment A plus 7 days at 40° F

C - treatment B plus 30 days at 10° F

D - treatment C plus 7 days at 40° F

After the samples from each treatment were removed from the cold chamber they were placed in a greenhouse for regrowth.

The temperature regime of this study proved to be too severe for the bluegrass-tall fescue mixture, and resulted in severe injury. The tall fescue was essentially killed by treatment A, and therefore was not statistically analyzed. There were a few tall fescue plants surviving after treatment A, and these were nearly always found in the low fertility samples. None were found in the high fertility samples.

Even though the bluegrass was more resistant to the cold treatment than the tall fescue, it was completely killed by treatment C.

In 1966 cold treatments were modified. Since it was believed that severe injury in the 1965 study may have resulted from abrupt temperature change, temperatures were raised and lowered at a rate of one and one-quarter degrees per hour for this study. Treatments in 1966 were as follows:

Cold treatment AA - 13 days at 12° Fahrenheit

BB - treatment AA plus 4 days at 40° F

CC - treatment BB plus 14 days at 12° F

DD - treatment CC plus 4 days at 40° F

The temperature conditions of this study were found to have no differential effect on the bluegrass, since neither the bluegrass crowns nor shoots changed among cold treatments at any fertility level.

Effect of Cutting Height on Cold Injury

Cutting height was found to affect both shoots and crowns of tall fescue and bluegrass at the 4 or 8 pound rate of nitrogen. At these fertility levels, bluegrass shoots and crowns were injured more at the three-inch than at the two inch cutting height (Table 3).

On tall fescue, the height of cut had the opposite effect than on bluegrass. The difference due to cutting height was significant only at the 4 pound nitrogen rate for tall fescue. More shoots and crowns survived the three-inch than the two-inch height of cut (Table 4).

The results of these data suggests that for maximum winter survival bluegrass should be cut at 2 inches if either 4 or 8 pounds of nitrogen per 1000 square feet is applied. Tall fescue should be cut at three inches if the four pound rate is used. If either grass receives no supplementary nitrogen, the cutting height appears to be insignificant. There also was no difference in winter survival of tall fescue at the two or three inch cutting height if eight pounds of nitrogen were applied.

Table 3. Effects of two cutting heights on bluegrass crown and shoot survival at three nitrogen levels in 1966.

Cutting height	Low (0 nitrogen)	Nitrogen Level Medium (4 lb. nitrogen)	High (8 lb. nitrogen)
		Number of crowns surviving	
2 inches	14	57	59
3 inches	10	25	24
		Number of shoots surviving	
2 inches	19	83	74
3 inches	14	26	34

L.S.D. for number of crowns surviving:

Cutting heights at medium fertility level	(.05)	8
	(.01)	11
Cutting heights at high fertility level	(.05)	14
	(.01)	20

L.S.D. for number of shoots surviving:

Cutting height at medium fertility level	(.05)	13
	(.01)	18
Cutting height at high fertility level	(.05)	19
	(.01)	25

Table 4. Effect of two cutting heights on tall fescue crown and shoot survival at three nitrogen levels in 1966.

Cutting height	Nitrogen Level: Low (0 nitrogen)	Medium (4 lb. nitrogen)	High (8 lb. nitrogen)
		Number of crowns surviving	
2 inches	22	5	2
3 inches	16	11	1
		Number of shoots surviving	
2 inches	27	8	2
3 inches	20	13	1

L.S.D. for number of corwns surviving:
Cutting heights at medium fertility levels (.05) 4
(.01) 5

L.S.D. for number of shoots surviving:
Cutting height at medium fertility level (.05) 5

Effect of Nitrogen Fertilization on Cold Injury

The level of nitrogen fertilization affected the response of bluegrass and tall fescue to the cold treatments. Tall fescue was reduced at all three fertility levels. The treatments receiving no nitrogen showed the least reduction, with about three times more reduction occurring at the 4 and 8 pound per 1000 square feet rates. There were no differences in reduction of tall fescue between the 4 and 8 pound rates (Table 5).

The bluegrass increased in percent composition after treatment at all three levels (Table 5). There was the least percent increase if nitrogen was not applied, with a higher percent increase at the 4 and 8 pound rates. Again, there was no difference between the 4 and 8 pound treatments.

Table 5. Effect of fertility on the percent change in bluegrass and tall fescue composing the samples after cold treatments in 1966.

Fertility level	Percent increase(+) or decrease(-)*: Bluegrass	Tall fescue
Low (0 nitrogen)	+20 a	- 4 a
Medium (4 pounds nitrogen)	+34 b	-34 b
High (8 pounds nitrogen)	+46 b	-47 b

*Means within a column followed by a different letter are significantly different at the 5 percent level using Duncan's Multiple Range Test.

Some pertinent conclusions that may be drawn from this study are:

1. A turfgrass consisting of a mixture of tall fescue and Kentucky bluegrass will gradually change to bluegrass when highly managed in a climate similar to that of Central Ohio.

2. The increase in bluegrass and decrease in tall fescue results, at least in part, from differential winter injury to the two species.

3. To maintain a bluegrass-tall fescue mixture with a minimum shift to bluegrass, no more than 4 pounds of nitrogen per 1000 square feet per year should be used. If the four pound rate is applied, the mowing height should be 3 inches.