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Proceedings

of the

18th Annual Northwest Turfgrass Conference

September 23, 24, 25, 1964
Burnaby, B. C.

NORTHWEST TURFGRASS MEMBERSHIP DUES

	Annual dues
Golf Courses—	
Less than 18 holes	$20
18 holes or more	40
Nursery, landscaping and ground spraying firms	20
Architects and engineering firms	20
Equipment and material supply firms	20
Participating membership	10
Associate membership	5
All others	20
Cemeteries—	
Less than 400 interments per annum	20
400 to 600 interments per annum	25
600 to 800 interments per annum	30
More than 800 interments per annum	40
Park Departments—	
Less than 150 acres total area	20
150 acres or more	40

1. Annual Dues payable on or before May 15th each year. Dues are based on annual due date nonprorated.
2. Membership includes registration fee for one person at Annual Turf Conference. Other persons from member organization registration fee $5.00.
3. NO INITIATION FEES ARE CHARGED.
4. Nonmembers may attend the annual Conference by paying $10.00 registration fee. For further information on dues, contact Northwest Turf Treasurer.

It certainly has been a privilege to serve as your President of the Northwest Turfgrass Association during 1963-1964.

I have been an active member since the Association was organized. It has been gratifying to watch the growth and progress of this organization down through the years.

The Turfgrass Conference held in Burnaby, B.C. this past September had the largest attendance ever. A good share of the people attending said it was our best conference. It seems that each year our conferences have been bigger and better than the previous year. Each year more people are realizing that Turfgrass management is a complex and finite business. In order to keep pace with the changes, we have to take part in Conferencs and work shops; as attendance has grown in the past it will grow in the future.

I would like to thank each Board member for their cooperation this past year and also to the committee chairman and my fellow officers.

I know that the Association is in good hands with your new President Ken Putnam and I know that the Association will give him the good support that has been displayed in the past.

Milt Bauman

Northwest Turfgrass Association

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PREVENTING POA ANNUAL INFESTATIONS

A. J. Renney
University of British Columbia

Because of the extreme difficulty of selectively eliminating annual bluegrass from other turf grasses and because it so readily reinvades even when controlled it would seem to be extremely important for us to prevent this weedy grass from becoming established if this is at all possible. New approaches and new chemicals for control will aid a great deal, but we will always have to be on guard against reinfestations. An understanding of the nature of this weed and the ecological factors associated with its growth is necessary both for the development of useful preventative procedures and before control measures can be used with maximum effectiveness. When reviewing our knowledge of *Poa annua* we are immediately aware of the fact that more questions than answers occur, but even bringing to light some of the things we don't know may serve a useful purpose at this time.

Initially then, let us say that we don't know for sure that *Poa annua* is an annual. Whenever greenhouse or coldframe investigations are set up using isolated plants not under mowing conditions comparable to those in established turf, our work at the University and that done at Saanichton supports the description of *Poa annua* as an annual. However, at the Agassiz Research Station perennial plants appear to occur in field turf plots and one authority in the mid western United States has observed that the weed acts as a perennial there. Associated with this concept of perennial habit is the observation made in several countries that stoloniferous growth accompanied by rooting at the nodes occurs, particularly in moist, fertile soils. Our studies have shown that 360 seeds per plant can be produced between May and August, but we have no records for other parts of the season, and seed production may continue all year in this climate. Counts made in Wales have shown that seeds of *Poa annua* as high as 30,000,000 per acre may exist on the surface layer of soil. The seeds are highly viable and do not exhibit the same dormancy after maturity as do those of Kentucky or Canada bluegrass. Adding these characteristics of many seeds per plant, little or no dormant period and high viability to the fact that this is the only known grass which can continue to produce seed under the low mowing heights which prevail on a golf green, we realize that we are faced with a formidable problem. If to this we also add the possibility of vegetative growth and perennial habit we compound the difficulty.

Like other seeds, *Poa annua* requires moisture, warmth and oxygen to germinate. Thus it does not germinate under a compacted soil layer but rather near or at the surface. In addition it germinates in greatest numbers when light is available—one reason it invades broken or open soil so readily. The seed is small, light and inconspicuous and readily moved on machinery, the soles and other surfaces of shoes, in pant cuffs in water and probably in between the toes and on the hair of small animals.

The other outstanding characteristic of *Poa annua* which may aid us is its shallow rooting habit. For the plant this is both a strength and a weakness. Annual bluegrass is able to invade and survive in conditions which would not support more desirable species. Conversely, in friable, deeper soils, and competing with well-established grasses of the more desirable types, *Poa annua* finds it much harder to colonize the area. Unfortunately. *Poa annua* and the bent grasses share very similar ecological requirements and the problem from this weed species is often quite severe in bent grass turf. The shorter mowing practice suitable for bent grass turf, for example, is favourable to *Poa annua* as the suppression which might come from the shade associated with higher mowing is at a minimum.

Disease has long been known as a factor in causing *Poa annua* to die out of turf areas. This susceptibility to disease is associated with the moist habitat just above the actual soil surface where mat develops. This area, which is largely composed of decaying organic material, is very favourable to the growth of micro-organisms. *Poa annua* has been observed to root almost entirely in this medium without the roots ever coming into contact with the actual soil. It may be true, unfortunately, that the use of fungicides could be prolonging the life of *Poa annua*.

With some of the aforementioned factors in mind, what then can be done by way of prevention? I feel these can be briefly summarized under the following headings:

Preseeding preparation
Seed
Management.

There is no need for me to detail the preparation of a seedbed, but it should be emphasized that good preparation is doubly important where a problem with annual bluegrass is anticipated. Soil preparation and seeding practices resulting in uniform and complete coverage by the desired grass go a long way to reduce the establishment of *Poa annua*. As an important part of the preparation process, soil treatment with calcium cyanamid or one of the liquid fumigants is required to reduce the possiblity of infestation from soil borne seed or plants. Similarly soil used for top dressing after establishment of the turf should receive the same sterilizing treatment before being applied. Following *in stitu* treatment of soil or the application of treated top dressing material disturbance of the soil should be kept to the absolute minimum so that seeds from untreated soil zones are not brought to the surface to germinate.

Are we seeding *Poa annua* innocently in the seed we buy? If *all* the seed we are allowed as "other crop seeds" in a grass sample was *Poa annua* maximum tolerances would permit the following under the Seeds Act of Canada.

Table 9 (Fescues, ryegrasses etc.)

Grade	*Poa annua* tolerance
Can. Reg. No. 1	5 seeds per oz.
" Cert. No. 1	2% by weight
" No. 1	2% " "
" No. 3	<5% " "

Table 10 (Bents and red top and blue grasses.)
Here *Poa annua* is listed as a crop species.

Can. Reg. No. 1	1% by weight
" No. 1	3% " "
" No 3	<5% " "

Table 12 (Lawn and turf grass mixtures.)

Can. No. 1 Mixture 3% singly or 5% combined* by wt.
" No. 2 " 5% " " 10% "

It must be emphasized that the attainment of these figures is highly improbable inasmuch as it is extremely unlikely that all of the "other crop seeds" would be *Poa annua*. In Penncross bent 15 other weed species are usually represented and in Kentucky bluegrass 90 other weeds occur and 21 other crop seeds. *Poa annua* is classified under the "other crop seed" category in the Seeds Act of Canada.

The Vancouver laboratory of the Plant Products Division, Canada Department of Agriculture, has furnished me with a considerable amount of information regarding the occurrence of *Poa annua* in grass seed. The 1963-64 crop has been broken down in detail to indicate the situation in a typical year. No seed of *Poa annua* was found in any of the following 9 grass types: Red top (64 samples), Highland bent (96 samples), Penncross bent (17 samples), Seaside bent (2 samples), Brown top bent (4 samples), Colonial bent (10 samples), Astoria bent (2 samples), Creeping red fescue (721 samples) and Chewings fescue (105 samples). However *Poa annua* did occur as a contaminant in seed of Perennial ryegrass (11 of 24 samples), Kentucky blue (7 of 25 samples), Merion blue (2 of 7 samples), Annual ryegrass (4 of 13 samples) and lawn grass mixtures (1 of 5 samples) in the 1963 crop. Over the period 1960-64. 138 samples of Kentucky bluegrass were analyzed of which 22 contained *Poa annua* and, in the same period, 148 samples of Merion blue were analyzed of which only 3 contained the weed seed. Thus it appears that annual bluegrass can be a contaminant of the ryegrasses, bluegrasses and lawn mixtures but does not appear to be a problem in red top, bents and the fescues. Size of seed would naturally have considerable bearing on these facts and *Poa annua* does appear in those samples which are similar to it in seed size and weight.

What about prevention in established swards? It would appear that this is one of those cases where we know what should be done but the difficulties associated with trying to do it are almost insurmountable.

We should keep bare areas to a minimum. No matter how little *Poa annua* seems to be growing on the fairways and in the rough we can always count on a seed source being close by.

We should keep traffic to a minimum, particularly in damp weather. Both compaction which favours seed germination and dissemination of the seed are encouraged by traffic. Alternate routes, larger areas, restriction of traffic—these come to mind as aids but are easier to suggest than effect.

Remove clippings. This is particularly important in areas where new infestations of *Poa annua* are developing so that spread can be restricted. However, we have noted that seed is set also below the level of the mower blade. Brushing the greens when the annual bluegrass is flowering has apparently aided in preventing seed set, particularly when this is accompanied by a thorough removal of clippings.

Keep thatch to a minimum. Removing clippings will, of course, aid here.

Aeration to encourage the growth of the desired species will also help it to compete against *Poa annua*.

Scarification when practical may be used to remove the relatively high-crowned, shallow-rooted *Poa annua* before it can shed much seed. Similarly a complete chemical renovation using Paraquat or similar chemical mowers followed by reseeding may be the only practical method of preventing spread.

The above suggestions, when used with the chemical control procedures which will be suggested by the next two speakers, should help in keeping infestations of *Poa annua* to a minimum.

THE ECOLOGY OF POA ANNUA, ANNUAL BLUEGRASS[1]

By Roy L. Goss[2]

In 1886, Haeckel, a zoologist, defined ecology as the study of the reciprocal relations between organisms and their environment. Ecology, however, is usually subdivided into animal ecology and plant ecology.

Plant ecology, according to ecologists, may be subdivided into *Autecology*, a study of the interrelations between the individual and its environment, and *Synecology*, a study of the structure, development, and causes of distribution of plant communities.

Since environment is so important in the definition of ecology, we must consider this term more carefully. Environment can be broadly divided into three major divisions, namely: (1) climatic, (2) soil, and (3) biotic, such as symbiosis and parasitism.

This paper shall be concerned specifically with some ecologic factors affecting the development of *Poa annua* (hereafter referred to as annual bluegrass) and likewise how these factors can be utilized in developing control measures for this plant. If we consider the three major factors above (climatic, soil, and biotic) as being the most important components of environment, let us examine them separately and assess their importance on annual bluegrass development and control.

CLIMATIC FACTORS AFFECTING POA ANNUA DEVELOPMENT:

A. **TEMPERATURE**—Annual bluegrass, as the name implies, is not a true annual. Under certain environmental conditions it behaves as a **winter annual** and otherwise as a perennial plant. A true winter annual is one that germinates in the fall, makes some development when conditions are favorable in the winter, then makes rapid early growth to physiological maturity in the early spring.

If conditions remain optimum for continued growth, annual bluegrass may continue living from year to year in a perennial condition. Temperature is one of the most important factors permitting the perennial habit. In the southwest, south, and midwest, high summer temperatures usually eliminate annual bluegrass plants. For this reason, turfgrass areas with a high percentage composition of this weed result in dead areas and sparse stands in mid season. However, seasons are known where summer temperatures in the above areas remainded low enough for annual bluegrass to continue growth. Except under unusual condition, summer temperatures never become a limiting factor for perennial growth of annual bluegrass in the Pacific Northwest.

Winter temperatures seem to play a less important role in annual bluegrass development than the summer conditions. Even so, fall germinated seedlings can fall victim to frozen, dessicated conditions in the midwest. Due to an abundance of seed, however, spring germination can rectify this problem.

Mild winter conditions west of the Cascade Mountains can cause a rapid build-up of annual bluegrass since there is no winter mortality.

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[1] 17th Annual Pacific Northwest Turfgrass Conference, Burnaby, B.C., September 23, 1964.

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In fact, some seed formation can be noted any month of the year in this area.

B. **MOISTURE**—This factor is primary to growth and development of annual bluegrass. Droughty sites virtually eliminate this species. Due to a very shallow rooting habit, annual bluegrass must have a more or less constant supply of moisture in the uppermost soil layer. For this reason, it finds a utopian condition in the Pacific Northwest, and particularly on golf course putting greens and protected north exposures. Annual bluegrass, however, does not require a soil moisture content higher than other grasses for its existence.

Unfortunately, the mowing height of grasses for certain uses, such as putting and bowling greens and professionally maintained lawns results in decreased root systems of desirable grasses, causing water requirements to be roughly the same as annual bluegrass.

Constant rain during the winter months on the Pacific Coast insures near ideal germination and development conditions for annual bluegrass over a long period of time. Likewise, these mild conditions encourage use of sport and recreational areas to the extent that permanent, desirable grasses may be placed in unfavorable competition.

Excessive moisture in heavy soils and poorly drained soils also create conditions favorable for *Poa annua*. If soils contain an excess of fines (silt and clay), these can be brought to the surface by foot and mechanical traffic. Shallow rooting of all species usually results, and annual bluegrass is favored. And finally, saturated soils contain little or no oxygen, hence, surface rooting occurs. Many times, this condition is brought on by over-irrigation and is *inexcusable* for the most part.

C. **LIGHT**—Most plants have a critical minimum light intensity for photosynthesis and other physiologic functions to occur. It has been quoted that grass requires about 420 foot candles of light for the conversion of nitrate nitrogen to other forms in the leaves of the plant. Not only are the physiologic functions of the plant closely regulated by light, but it also exerts many stimulating effects upon the *differentiation* of tissues and organs. It has been said that light is rivaled only by water in its influence upon the morphology and anatomy of plants.

Light intensity can become a limiting factor in turfgrass management. There is always a greater intensity in dry climates than in humid. Hence, a great difference between areas east and west of the Cascade Mountains. Light intensity west of the Cascades becomes critical for plant growth beginning with the wet fall, winter and early spring months. Intensities of no more than 200 foot candles have been recorded in December in problem areas and values of 1000 F.C. are the exception rather than the rule on cloudy days. Trees, buildings, and topographic variations also reduce the amount of available light.

Annual bluegrass can survive and produce viable seed under lower light intensities than any other turfgrass in the northwest. This is in evidence when we examine the botanical composition of turf under shade and on the north sides of buildings where light is mostly of the diffuse type and rarely any direct. Many commercial spray applicators have discovered to their sorrow that this change occurs in small areas. Often, annual bluegrass is killed outright by herbicides required to effectively eliminate broad leafed weeds while causing little or no damage to the desirable turfgrasses. Not only is this weed favored in these areas due to the light intensity, but a high moisture level is usually a concomitant factor.

SOIL FACTORS AFFECTING POA ANNUA DEVELOPMENT:

A. **SOIL TEXTURE**—Light soils (sandy) are droughty and heavy soils (loam, silt loam, etc.) are potentially wet soils. Well drained light soils can discourage the development of annual bluegrass and other shallow rooted species since the surface can be kept dry enough to be sub-optimum for growth. These conditions will encourage deeper rooting of the normally deep rooted perennial species.

What may be a light textured soil for one use may become a heavy one for another. As an example, athletic fields and putting greens would soon encounter problems with a sandy loam soil, whereas this is perhaps the most desirable soil for the average home lawn, cemetery, or golf course fairway.

Sandy loam soils can contain 25% or more of combined silt and clay. Silt and clay particles contribute greatly to the water holding capacity of a soil and the higher the percentage in any given zone, the wetter the soil becomes. When excessive foot and machine traffic is induced on these heavier soils, the fines (silt, clay, organic matter, and even fine sand) may migrate to the surface layer causing a sealing condition and resulting in wet and soft conditions during rainy periods and after irrigation, and compacted slowly permeable conditions otherwise.

For these reasons, annual bluegrass is favored under most maintenance programs especially during the wetter months west of the Cascades. The other extreme of a soil becoming too light can also occur and must be avoided whenever possible. Sands can be modified in their nutrient and water holding capacities by the addition of organic matter; but we must remember that organic matter can hold up to nine times its weight of water, which is more than silt and clay.

B. **STRUCTURE**—The arrangement of soil particles denotes the structure of a soil. Since compaction, puddling, and other manipulations of soil can break or alter the structure, it becomes less of a factor in most turfgrass soils. In fact, sand is said to be single grained or has no structure. Hence, we are little concerned, in the surface of the soil especially.

Compaction on most recreational and athletic areas usually does not occur deeper than 2-3 inches. Soils, then, should retain some structural characteristics of aggregation below this depth. The pitfalls of loss of structure and migration of fines as they affect annual bluegrass have been pointed out in the section under texture.

BIOTIC FACTORS AFFECTING POA ANNUA DEVELOPMENT:

Under this section, a multitude of factors could be introduced that would affect the development of annual bluegrass; however, we shall consider those most commonly encountered in management practices in the northwest. Unfortunately, most of these factors are caused by man and a few by other causes, as follows:

A. **ADAPTED GRASS VARIETIES**—If the turfgrass manager does not plant the best adapted varieties for his locality, it is probable that reduced vigor will result in annual bluegrass invasion. As an example, Kentucky bluegrass planted west of the Cascade Mountains is replaced by annual bluegrass and bentgrass, usually, within 2 or 3 years. Also the Kentucky type bluegrasses are subject to rust and diseases, resulting in invasion. The fact that perennial bluegrasses go into a winter dormancy, allows annual bluegrass and the bents to dominate.

Athletic (football) fields are particularly subject to annual bluegrass domination. Here again, the right species or variety for the area will help prevent this. For a good football turf, we must have a tough, durable, deep rooted, and a quick recovering grass to withstand this use (or abuse), particularly during the dormant season.

B. **MOWING**—This is perhaps one of the most contributing factors of *Poa annua* domination. The frequency of mowing has little effect on reseeding by the plants as reported by Dr. Youngner in California. This is due to the low to prostrate growth habit, allowing ample seed to be produced near the ground surface.

The *mowing height* is more closely related to annual bluegrass domination, however. There is an optimum height at which most plants make their best growth in both shoots and roots. Any decrease in mowing height will favor annual bluegrass. This is particularly evident in closely mowed putting greens but is not nearly so bad in lawns which are mowed at ½ inch or higher, where the desirable grasses are bent and/or fescue. This becomes increasingly important with ryegrass and tall fescue on athletic fields.

C. **AERIFICATION, VERTICUTTING, AND LIGHT RENOVATION**—Any mechanical injury that does not heal rapidly leaves invasion routes for annual bluegrass. This is especially true in areas where grasses are dormant during the winter months. Dr. Youngner has previously reported this in California. In fact, the recommended method of overseeding thin turfgrass areas in the northwest is to aerify, verticut, or lightly renovate the area, then broadcast a desirable grass seed to strengthen the stand. As is the case with *Poa annua,* ample seed is always available for colonizing bare or thin areas.

D. **EFFECT OF DISEASES**—Fusarium patch, red thread, fairy ring, snow mold, and now ophiobolus patch inflict considerable damage to managed turfgrasses annually. Again, due to the abundance of annual bluegrass seed ready to fill in these bare areas, it can completely dominate if the diseases are not controlled. Experiments are currently underway to determine the disease effect more specifically.

Fusarium patch, which is particularly severe in areas west of the Cascades, is most active during the favorable germination period of annual bluegrass. Likewise, a favorable period for the germination of this weed occurs in areas east of the Cascades following severe activity of snow mold. This does not imply that *Poa annua* is resistant to these two diseases for such is not true. In fact, it is equally as susceptible as any of the bentgrasses, but due to its prolificacy, it can replace other grasses, as well as itself.

E. **THE EFFECT OF TOXIC SUBSTANCES**—Turfgrass areas killed or severely injured by toxic substances are open to invasion by annual bluegrass. Some of these substances are fertilizers, herbicides, fungicides, and insecticides. If the loss of turf is due to a fertilizer burn, the reinvading species should find fertile growth conditions, especially in the case of nitrogen.

Another instance of a toxic substance may possibly occur as a toxin produced by **Poa annua** itself. It is possible that such a substance could exist and eliminate or reduce other species from becoming established. This phenomenon is referred to ecologically as **autibiosis,** and is known to occur in numerous ways. If such a toxin is produced by annual bluegrass, then a positive control would be of increasing importance.

PRE- EMERGENCE CONTROL, A CHEMICAL PROGRAM AFFECTING POA ANNUA DEVELOPMENT

Attempts to control annual bluegrass with pre-emergence chemicals has been in progress for many years. Perhaps this approach in the control of this weed is an off-shoot of pre-emergence crabgrass control. Dr. Daniel of Purdue reported good success in the control of annual bluegrass with arsenic materials, but found that under certain environmental stresses that desirable turf was severely injured or killed as well. Goss has found that lead arsenate applications resulted in greater toxicity to bentgrass seedlings than to annual bluegrass. Furthermore, the effects of arsenic are more or less permanent in the soil and applications of this material as a regular practice should be discouraged or prevented.

Armed with many of the foregoing facts, a research program has been in progress at the Western Washington Experiment Station at Puyallup, Washington, for the last four years in an effort to select chemicals known to have pre-emergence control properties. These materials were applied to plots in a plastic air supported green house that were planted to both bentgrass and annual bluegrass at intervals up to 9 weeks in duration. All experiments were terminated by 16 weeks at the latest. The following table illustrates the effectiveness of these materials in their control of annual bluegrass.

The important factor to note is that in experiment No. 5, only Dacthal, Zytron, Trifluralin, Betasan, and Enide were used. The other materials were previously eliminated because of phytotoxicity to established turf or ineffectiveness of control.

Since these data were recorded, additional trials have shown that Azak and one or two experimental materials are likewise showing considerable promise for pre-emergence control.

The effect of pre-emergence herbicides on the control of annual bluegrass seedlings planted 1 day, 3, 6 and 9 weeks after treatment and rated 3 weeks after planting.

Treatment	Rate Lbs. A.I./A.	Observed Annual Bluegrass Control (1=mone, 10=Complete)* Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5
Check		1.0 g	1.0 h	1.0 c	1.0 c	1.0 b
Dacthal	2	3.5 f	3.8 g	—	—	—
"	5	8.3 c	7.8 e	—	—	—
"	10	9.0 b	9.5ab	8.3ab	9.3ab	8.5a
"	15	8.8 bc	9.3ab	7.5 b	9.0ab	8.5a
"	20	—	—	8.3ab	—	—
Zytron	10	8.8 bc	9.5ab	—	—	—
"	15	9.0 b	8.8 bc	8.3ab	8.5 b	9.3a
Dipropalin (2% gran.)	4	5.8 d	8.3 cd	7.5 b	—	—
Dipropalin (E.C.)	6	—	—	8.3ab	9.0ab	—
Trifluralin	2	—	—	—	8.3 b	9.0a
"	4	—	—	7.8 b	—	—
Betasan	15	—	—	—	—	9.3a
Enide	4	—	—	—	—	9.3a
Casoron	2	—	—	8.0 b	—	—
"	4	10.0a	10.0a	9.3a	—	—
Fenac	6	8.3 c	10.0a	7.8 b	10.0a	—
Neburon	4	3.8 f	6.3 f	—	—	—
Vegadex	6	4.8 e	4.8 g	1.0 c	—	—
TBA	3	1.0 g	1.0 h	—	—	—
Velsicol B	3	1.0 g	1.0 h	—	—	—
Dicryl	6	—	—	—	1.5 c	—

*Within any one column, means followed by the same letter do not differ at P = 0.05.

The effect of these materials is predominantly one of root toxicity, especially to embryonic or primary roots. If no root system can extend beyond the toxic soil layer, the plant may not die readily, but will certainly remain stunted and susceptible to death from environmental extremes.

Any good pre-emergence control program must consider these important steps:

1. How long is the material toxic? Most are good for 9-14 weeks, however, Betasan has shown residual effect for 1 year.
2. When must the material be applied? Certainly, we must encompass the germination period of annual bluegrass. August 15 applications will cover the late summer and fall germinating plants, and February 15 will cover the spring period. If the material has a residual life of 12 weeks, then applications at both of these periods would be in order. The ones with longer residual effect may be used once yearly.
3. When is it safe to overseed? Only when you are sure the toxicity has gone. If the chemical is applied in February, no planting should be done before about June 1.
4. It is obvious that a good disease control program must be exercised if pre-emergence chemical control is practiced. Overseeding due to turf loss from diseases should be timed for the period of no chemical toxicity.
5. These materials appear to be safe in preliminary trials in establishing turf from stolons. This is apparently due to morphologically different roots as compared to seedling or embryonic roots.

SUMMARY:

There is no panacea nor sure-fire means of controlling **Poa annua**, but a knowledge of some of the factors such as climate, soil, and the biotic factor, including man, will aid materially in controlling this weed and promote better quality turf.

Chemical control, here, as in other crops and other pests, appears to be our best approach today, but the use must be tempered with sound research, a good working knowledge, and a practical approach at all times.

FERTILITY EFFECTS ON DISEASE DEVELOPMENT

A great amount of work has been done over the past several years with the turfgrass diseases. A considerable amount of knowledge has been gained on the effect of fertilizers and other factors on disease development.

In recent years work has been conducted through the Western Washington Experiment Station at Puyallup and papers have been published regarding the control of Fusarium Patch caused by the fungus Fusarium nivale (1). One of the studies incorporated into this experiment on the control of Fusarium Patch was the effect of Fertilizers both intensity and ratio upon the development of this disease. The results of these studies indicated that the level of nitrogen applications as well as the source of nitrogen could greatly influence the amount of disease development. In all cases the higher levels of nitrogen caused much more Fusarium development.

In these experiments it was also observed that when nitrogen was obtained from urea that more disease developed than when other sources of nitrogen were used. Likewise some of the organic source nitrogenous materials increased the amount of Fusarium development during the early fall.

THE EFFECT OF FERTILITY ON OPHIOBOLUS PATCH
(Ophiobolus graminis)

The fungus *Ophiobolus graminis* causing the disease Ophiobolus Patch was first identified in Washington in November, 1960 (2). Even though the disease was previously reported in England, it has not been a serious problem elsewhere in the United States according to literature.

In fertilizer plots at the Western Washington Experiment Station, a variable intensity of Ophiobolus development was observed within the different fertilizer treatments. A closer watch was kept thereafter on the diseased area to determine what possible effects nitrogen, phosphorus, and potassium could have upon the development of this disease.

EFFECTS OF FERTILITY ON OPHIOBOLUS PATCH DEVELOPMENT

	Disease Rating[1]	
Plot No. and Fertilizer Treatment	January '62	September '62
1. 20-0-0	4	7
2. 20-4-0	5	6
3. 20-4-4	6	6
4. 20-4-8	4	6
5. 0-0-0	0	1
6. 20-0-4	4	5
7. 20-0-8	5	5
8. 12-0-0	3	2
9. 12-0-4	2	2
10. 12-0-8	3	2
11. 12-4-0	2	2
12. 12-4-4	2	1
13. 12-4-8	3	0
14. 6-0-0	1	3
15. 6-0-4	0	0
16. 6-0-8	0	0
17. 6-4-0	1	0
18. 6-4-4	0	1
19. 6-4-8	2	2

[1] Disease rated is Ophiobolus patch caused by *Ophiobolus graminis.* Ratings are from 1-10. A rating of 10 is severe, more than 40% of the plot being infected.

From the table above it is obvious that the amount of nitrogen applied is the important factor in this case. Perhaps the source of nitrogen is just as important; however, source experiments have not been conducted at this time. The source of nitrogen in these experiments is from urea alone. Urea is being used since all fertilizer applications on these plots with the exception of phosphorus go on as spray treatments.

As the rate of nitrogen application decreases so does the amount of infected or diseased area. When this disease first appeared it was even more pronounced on the higher fertilized plots. However, as time progresses the disease seems to become more generally widespread.

FERTILITY EFFECTS ON RED THREAD (Corticimum fuciforme) DEVELOPMENT

In trials conducted at Puyallup for two years, it has been shown that higher rates of nitrogen serve as good control measures for red thread during the growing season. Since this disease causes a leaf tip burning or browning effect, subsequent growth and removal of infected parts by clipping produces a desirable appearance. Nitrogen will produce this growth effect as long as other elements are present in sufficient amounts.

This does not imply that no fungicidal or other controls are necessary since the disease can become serious at times in the fall even on well fertilized turf. However, a good fertilization program is important throughout the growing season.

Conclusions

There are no definite conclusions upon these studies at this time. An experiment is being set up currently to study Ophiobolus Patch in more detail. However, from two years of observation we can generally conclude that the higher the amount of nitrogen the greater the infection from Ophiobolus Patch will be particularly in the early stages of development. At this time there seems to be little interaction between phosphorus and potassium with nitrogen on the incidence of this disease, however, these factors will be investigated more thoroughly in the future.

One interesting observation during the summer of 1962 has been the occurrence of white mold in certain plots throughout the fertilizer experiment. This white mold is believed to be caused by a Basidiomycete. Some problems of a rather serious nature are occurring along with this disease. These areas seem to be puffing more and are being scalped by the mower. Recovery is generally quite slow. The treatments affected worse in this case are number 10, 12, 13, 15, 16 and 18. It may be concluded here again that nutrition may be a factor in the development of this particular problem.

1. Fungicidal Tests For The Control Of Fusarium Patch Disease Of Turf by Gould, C. J., Goss, R.L., and Miller, V. L. Plant Disease Reporter 45:2, February, 1962.
2. Gould, C. J., Goss, R. L., and Eglitis, Maksis. Ophiobolus Patch Disease of Turf in Western Washington. Plant Disease Reporter 45:4 April, 1961.

LIMITING FACTORS IN SELECTIVE ANNUAL BLUEGRASS CONTROL

By Norman Goetze
Extension Farm Crops Specialist
Presented at Northwest Turfgrass Conference

Development of a desirable method for the selective control of annual bluegrass in desirable turf species is dependent upon using one or more of the principles of selective toxicity. Selective toxicity is defined as the practice of injuring one species of living matter without harming another species with which the first is in intimate contact. In the case of controlling annual bluegrass in turf, we would like to completely remove annual bluegrass without damage to the desirable turf species or any of the users of the turfgrass.

Selective toxicity can be influenced by morphological differences between bluegrass and the other turfgrasses on the basis of differences in root growth, locations of growing points or depth of rooting. Physiological differences may be related to the presence or absence of the specific enzymes or by the presence of detoxifying agents in the resistant species. Periodicity of growth, especially in the case of annual bluegrass being an annual or a short lived perennial, allows the use of materials which are especially effective on emerging seedlings.

The perfect annual bluegrass herbicide should be completely selective with absolutely no damage to other species. It should be long in residual activity and it should be equally active on all types of soil and climatic conditions found under turf conditions. Obviously, the perfect herbicide will never be found, but there has been some recent research results which may be of interest.

Much of the early annual bluegrass control results were obtained from research where soil active herbicides were sprayed on the bare surface and artificial populations of annual bluegrass were seeded prior to or immediately after application of the herbicides. There are dozens of chemicals which will control annual bluegrass under these conditions, but the results are not very typical of turf conditions. Very little turf is produced on bare soil with all annual bluegrass seed emerging over a short period of time.

Some very promising annual bluegrass control methods have been developed in turfgrass seed fields. Most of these effective materials, such as the carbamates, substituted ureas, and triazines, do not cause any permanent damage to a stand of turf seed crops. They are applied at a season when top growth is not very active and minor damage is not objectionable in seed production. Much basic work on the ecological factors of soil type, rainfall distribution, exposure to high light intensity and soil inactivation by either ashes or organic matter, have been worked out.

The early annual bluegrass control work under turf conditions showed that metallic arsenicals had greatest promise. These materials, when left on the surface of the soil, prevented the development of young seedlings of annual bluegrass. Lead arsenate was found to be more selective, but required heavier application rates than did calcium arsenate. Much damage has been experienced, especially to creeping bentgrass, from calcium arsenate. The substituted ureas, mainly diuron and neburon, have shown limited promise under turf conditions, but their selectivity is greatly influenced by soil type and temperatures. Much lower rates of application on sandier soils and in higher temperature areas could be tolerated.

Richard Schwabauer completed studies in 1963 at Oregon State University on the interaction of soil mixtures and soil covers on the length of residual activity of several promising annual bluegrass herbicides. He found betasan to be least influenced by either soil type or soil cover and to have the best residual activity. Dacthal activity was influenced slightly by soil type and did not give as long residual activity. Four other materials gave excellent annual bluegrass control, but were either damaging to desirable turfgrass or were removed from development by the organizations developing them.

In field trials during the 1963 season, Tom Neidlinger found diuron and betasan to give the best selective control of annual bluegrass in Kentucky bluegrass seed fields. Some damage to bluegrasses was incurred when surface water was impounded for a long period of time. Reasons for this damage have not been determined and additional plots are being established this season to investigate this problem. Diuron cannot safely be used on turfgrasses for reasons mentioned earlier. Dacthal caused slightly more damage than betasan and did not give as good selective control as betasan. Trifluralin gave excellent control of annual bluegrass but caused far too much damage to common Kentucky bluegrasses.

In summary then, betasan is showing the best promise for control of annual bluegrass in turf conditions, at least on its length of residual activity and equal effectiveness under all soil conditions.

Shorter residual life soil chemicals could be used if more were known about when annual bluegrass germinates. Present studies are pointing that annual bluegrass can germinate under almost all turf conditions in the northern Pacific region. In some laboratory trials, annual bluegrass has been successfully germinated at 34°F, but of course the rate of germination is much lower. If the seeds can be kept adequately moist, it can also be germinated at temperatures as high as 90°F. When annual bluegrass actually germinates in the field has not been carefully determined under actual growing conditions. Some preliminary studies of this nature are now in progress.

Additional work that is needed on annual bluegrass includes a comprehensive collection of strains of annual bluegrass. Preliminary evidence indicates that there are many different ecotypes of this species and that some of them would react quite differently when moved out of their natural habitat. Similar differences in reaction to selective herbicides might be predicted.

PERFORMANCE OF RED FESCUES FROM THE NORTHWEST

W. E. P. Davis

Experimental Farm, Canada Agriculture, Agassiz, B.C.

The bulk of the creeping red fescue seed produced in Canada is grown in the Peace River region in the provinces of British Columbia and Alberta. It is generally considered that this seed originated from the variety "Olds", well-known for its winter hardiness.

In turf trials at Agassiz, B.C. over a period of twelve years, Olds has shown considerable susceptibility to disease, in particular Red Thread, *Corticium fusiforme* (Berk.) Wakef. However, in seeding made in 1962 and 1963 this susceptibility appeared to be greatly reduced and the overall vigour of the turf improved.

This change in the characteristics of turf from northern seed could be due to many things; to a general improvement in the seed being sown; to differences in seed lots produced in different parts of the Peace River region (ecotypes); or to seasonal conditions favourable to the production of seed from only one plant type within the seed fields in any one year. With these possibilities in mind, a study was undertaken at Agassiz, B. C. in 1963 with northern grown red fescue seed obtained (1) from seven commercial growers in the Peace River region.

Materials and Methods

The test area was roto-tilled out of a turf killed with 3 pounds per 100 sq. ft. of methyl bromide applied under plastic. The area was treated with 4.5 pounds of 2.5 percent Aldrin dust worked into the soil. Twenty-five pounds of a complete fertilizer (13-16-10) was applied and roto-tilled throughout the soil. The pH of the soil was approximately 6.2.

The test was planted broadcast on September 3, 1963 at a rate of 4 pounds per 1000 sq. ft. The unreplicated plots were 10' x 10' comprising a total area of 20' x 60'. Twelve red fescues in all were seeded: 7 northern grown seed lots and 5 varieties. These were as follows, northern grown: Sexsmith I, Alta, Dawson Creek. B.C.; Sexsmith II, Alta., Valhala, Alta.; Ryecroft, Alta.; Rose Prairie, B.C.; Farmington, B.C. And varieties of red fescue: Reptans (Sweden), Polar (Sweden), Pennlawn, Duraturf, and Illahee. The latter three varieties were certified No. 1 seed.

Yields of dry matter were obtained by weekly mowings of one swath per plot, with the same area being mown each week. The size of the swath was 1.8' x 10', and the mower was set at a height of 1¼". The amount of nitrogen removed in the clippings was determined by drying the grass at 100°C, grinding, and analyzing for nitrogen using the Kjeldahl method. Other agronomic data were obtained by means of either visual

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(1) Seed was obtained through the courtesy of Mr. D. W. Thompson, of the Brackman-Ker Milling Co. Ltd., New Westminster, British Columbia.

estimates or measurements.

Fertilizer was applied with a Gandy spreader calibrated to spread at rates considered adequate in this area for good growth and healthy grass. Dates of application and amounts per 1000 sq. ft. are given in Table 1.

To permit evaluation of disease infestation, particularly Red Thread, no fungicide was applied to the test area.

Irrigation was not required due to the frequent rains over the mowing season.

Table 1. Rates and Dates of Fertilizer *Applications to Turf at Agassiz, B.C. 1964.

Dates	Pounds per 1000 sq. ft. N	P_2O_5	K_2O
March 19	2	2.6	1.6
April 15	1	.0	.0
April 30	1	.0	1.0
May 15	1	.0	.0
June 1	1	.0	1.0
June 20	1	.0	.0
July 6	1	.0	1.0
July 28	1	.0	.0
Total	9	2.6	4.6

*All fertilizer was inorganic.

Discussion and Conclusions

The agronomic data presented in Table 2, while not replicated indicates to a marked degree the similarity between the fescues from the seven northern sources. The seedling vigour data obtained from assessments made 17 days after seeding and in 4 months' time displays not only this similarity but also the greater vigour of the 7 northern fescues in comparison to that of the 5 fescue varieties. These findings are substantiated by the height measurements taken in January, 1964. It should be stated that the two swedish varieties have not been tested previously at Agassiz, B.C. Thus, it is not known whether this is the normal vigour of these varieties or the exception. In the case of Pennlawn, previous trials displayed its vigour to be much greater than that of either Illahee or Duraturf.

The weed ratings taken this fall reflect to a degree the bearing that vigour has on resistance to weed invasion. The exception to this was Pennlawn with the lowest weed invasion of the test.

Sward density determined by removing plugs and counting tillers correlated very closely with density assessments made from the "feel" of the turf. Pennlawn had the densest turf, which might indicate a relationship between density and resistance to weed invasion. However, Polar also had a dense turf which, in view of its low resistance to weed invasion, does not bear out the previous statement. This latter variety had much finer tillers than the other fescues in the test and its growth, as is indicated by the dry matter data in Table 2, was slower. Which probably indicates that density and rapidity of growth or vigour are major factors relating to the weed resistance of a fescue variety. Regarding the 7 northern fescues, a marked similarity between them is indicated by the density data. This similarity extends to Duraturf, a selection out of the variety Olds.

The data for total dry matter and nitrogen in Table 2, again indicates the lack of a real difference among these northern fescues. The high dry matter production obtained from Pennlawn and Illahee represents the more normal vigour of these varieties than did the vigour ratings previously discussed.

Table 2. Growth and seasonal data for c.r.f. turf at Agassiz, B.C. 1963 and 1964.

Fescue sources or varieties	Vigour 9-20-64 (0-9)[1]	Vigour 1-10-64 (0-9)	Height 1-10-64 (inches)	Weeds 9-17-64 (0-9)	Density[2] 8-12-64 Tillers	Yield (Apr 8-Aug 11) Dry M. Lbs./1000 sq. ft.	Yield (Apr 8-Aug 11) N. Lbs./1000 sq. ft.
I.							
Sexsmith, Alta.	8	9	3.0	4.0	73	108	3.6
Dawson Creek B.C.	6	8	2.75	6.0	73	108	4.0
II.							
Sexsmith, Alta.	5	8	2.50	6.0	72	105	4.0
Valhalla, Alta.	6	8	2.25	5.0	78	103	4.0
Ryecroft, Alta	6	8	2.75	5.0	73	107	4.1
Ross Prairie, B.C.	7	9	2.25	4.0	68	106	4.7
Farmington, B.C.	7	6	2.75	6.0	73	106	3.9
Sweden Reptans	3	6	2.37	8.0	60	106	4.0
Sweden Polar	2	4	1.25	7.0	121	93	3.6
Pennlawn	2	6	1.50	2	134	112	4.3
Duraturf	5	8	2.0	5	75	103	3.8
Illahee	4	5	1.50	3	81	112	4.3

[1] 0-low, 9-high
[2] Tillers per 2" x 2" plug, average of 12 plugs.

The disease, Red Thread, failed to establish itself in these plots even though the disease was present on turf in close proximity to the test area. Thus, no data could be collected on the response of the northern fescues to disease, which was one of the main reasons for establishing the test.

The color of the plots varied little over the mowing season and differences between the 12 fescues were so slight that it was of no great significance. However, looking at the data in Table 3, it can be seen that the amount of nitrogen removed in the clipping was never equal to the nitrogen applied at any one fertilizing interval. This, at a first glance would indicate that the rate of nitrogen applied was in excess of the requirements of the plants. But, at no time during the mowing season did the turf reach the desirable full, dark green color indicative of high nitrogen fertility. Furthermore, the weekly mowing data for dry matter (not presented) indicated a fall off in yield of dry matter and in most instances a decline in the percentage of nitrogen in the clippings. This would suggest that nitrogen was not in excess but was being leached by rain or for some reason not available to the turf.

This somewhat preliminary work with the northern red fescues, while showing the uniformity of seed from the 7 sources, does not prove or disprove the possibility of a seasonal influence on the type of seed produced in this or other regions in any one year. Furthermore, to study this factor more fully, seed from a given source should be obtained yearly and tested over a period of five or more years in row plantings as well as under a mowing regime. This, to determine the genotypic response of the variety to enviroment.

Table 3. Yield of dry matter and nitrogen removed by weekly mowings of red fescue turf for the periods between fertilizer applications in pounds for 1000 sq. ft.

Sources and Varieties	Dates of fertilizer application and rates of NPK per 1000 sq. ft.															
	March 19 (NPK) 2-2-6-1.6		April 15 (NPK) 1-0-0		April 30 (NPK) 1-0-0		May 15 (NPK) 1-0-0		June 1[1] (NPK) 1-0-1		June 20 (NPK) 1-0-0		July 6 (NPK) 1-0-1		July 28 (NPK) 1-0-0	
	DM	N	DM	N	DM	N	DM	N	DM	N	DM	N	DM	N	DM	N
Sexsmith, Alta. I	6.9	.30	9.6	.37	11.1	.53	22.0	.92	19.0	.47	15.3	.60	18.3	.64	5.4	.20
Dawson Creek, BC	7.4	.34	10.0	.38	10.3	.47	21.4	.87	19.8	.50	16.0	.65	17.2	.61	5.7	.22
Sexsmith, Alta. II	7.1	.33	10.4	.39	10.0	.47	21.5	.88	17.0	.48	14.6	.59	18.2	.67	6.3	.24
Valhalla, Alta.	7.8	.37	9.5	.34	11.1	.50	22.4	.91	14.9	.46	14.4	.58	17.3	.65	5.5	.21
Ryecroft, Alta.	6.6	.30	10.7	.41	11.1	.51	22.5	.93	18.5	.46	14.1	.58	17.9	.66	5.7	.21
Rose Prairie, BC	7.6	.35	9.9	.38	10.8	.50	22.5	.94	18.5	.50	14.6	.62	16.5	.60	5.7	.21
Farmington, BC	7.6	.37	11.3	.45	12.3	.58	15.7	.55	20.5	.42	17.3	.76	15.7	.60	5.8	.21
Sweden, Reptans	6.3	.30	9.9	.41	10.6	.50	16.4	.58	20.5	.49	18.3	.77	18.2	.71	5.5	.21
Sweden, Polar	1.7	.08	7.5	.32	11.5	.57	14.7	.52	18.5	.44	13.9	.66	19.9	.82	5.3	.20
Pennlawn	7.6	.22	11.2	.49	12.9	.62	16.3	.60	20.6	.50	17.4	.78	20.3	.82	6.1	.24
Duraturf	5.5	.27	9.9	.41	10.9	.54	14.3	.51	21.5	.50	17.5	.76	17.7	.64	5.5	.21
Illahee	4.7	.24	10.2	.42	12.8	.61	17.8	.65	20.7	.51	18.5	.83	21.1	.81	6.3	.24
Mean	6.4	.29	10.0	.40	11.3	.53	18.9	.74	19.2	.48	16.0	.68	18.2	.68	5.7	.22

[1] Nitrogen date missing for the last week in this period.

TURFGRASS VARIETIES FOR THE INTERIOR OF BRITISH COLUMBIA

Alastair McLean
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Presented at the Northwest Turf Conference, Vancouver, Sept. 23-25, 1964.

My sincere thanks go to golf pros Rod Palmer, Dave Crane and Bill Carse of Kamloops, Kelowna and Penticton respectively, for their co-operation in testing some of the bentgrass varieties and for passing on the benefit of their observations over the past few years.

Golf Greens

At the Experimental Farm, Kamloops, eighteen bent grass varieties were tested for fine turf from 1958 to 1962, inclusive. The outstanding varieties were: Congressional, Penncross, Colonial, Cohansey, Waukanda, (others were Highland, Seaside, Toronto, Metropolitan, Velvet, S-5037 (from Saskatoon), Northland, Arlington, Islington, Astoria, Collins, Washington and Old Orchard. There is no longer any turf research going on in the Interior to my knowledge.

The biggest problem was that of snow mold (*Fusarium nivale*, and *Typhula* sp.), which nearly put the Kamloops Golf Club out of bent grass turf in the first few years until a satisfactory control program was worked out. Cohansey proved very resistant. The most severely damage varieties were Highland and Astoria. Penncross and Colonial were moderately hard hit. Good control was obtained with mercurial fungicides at recommended rates but applied early and late fall and again in the spring as necessary; whenever the conditions for the growth of the fungi appeared favorable during the fall and spring. Improved management practices including postponing fall fertilization until after all growth stopped and raising the cutting height in the fall also helped. This example demonstrates the importance of considering the overall management program and the ecological requirements of the turf in dealing with any specific phase of that program, such as pest control.

With respect to earliness of growth in the spring, Cohansey, Seaside, and Highland appeared the earliest, closely followed by Congressional and Waukanda. Cohansey and Congressional held their color well into the fall. Most varieties normally had a good dark-green color with the exception of Cohansey which was medium to light green in contrast.

Cohansey, Congressional, Penncross, and Waukanda all healed damaged patches in the turf quickly. Colonial, of course, was at a disadvantage in this regard.

Once the snow mold problem was under control the superior varieties remained relatively weed free.

In summary then, Cohansey was one of the most hardy varieties forming a dense turf. It was one of the earliest in the spring, a fast grower, and held good color retention late into the fall. The most serious disadvantages were its rather undesirable light color and a tendency to thatch.

Congressional was undoubtedly the best all-round variety; healing quickly and carrying an excellent color late into the fall, as well as having good texture. Penncross, which was grown from seed, was fair in performance but not too uniform, probably as a result of its being grown from seed. It crept strongly and had a tendency to thatch and be unsightly on close cutting.

Colonial was one of the best all-round varieties except for the disadvantage of not being able to heal over damaged areas quickly. It kept a fine color late into the fall and had a fine uniform texture. It also does better than most varieties on non-acid soils.

A word of caution; our soil and climate are so different in the interior that many practices used at the coast can be very detrimental there. For example, liming is unnecessary or harmful except under very unusual circumstances. I have seen lawns killed by liming slimy or mossy soils; conditions which may be caused by compaction and low fertility as well as acid soils.

Lawn, Tee and Fairway Grasses

Ten varieties of bluegrass and fescue were tested from 1958 to 1962 inclusive for use on tees, playgrounds, and home lawns. The varieties were Chewings, Creeping Red, Kentucky, Merion, Newport, Northwest, Delta, Pennlawn, Ilahee, and Alta.

The bluegrasses form the basis of most mixtures in the interior. Selections of Merion were outstanding in this regard. Although Merion was rather coarse in appearance it had an attractive dark green color with a springy turf. It had a bright straw color in winter and early spring which is rather objectionable. It appeared to need heavy fertilization in order to retain its good color. It established slowly but filled in rapidly with very strong vigorous rhizomes, almost to the point of being weedy.

A Northwest selection from Pullman, Washington established readily, had a good dark color, forming a finer turf than Merion and Newport, but not so fine as Kentucky. It had a greyish white color during the winter and early spring. It appeared to retain its green color longer in the fall and held up better in the hot weather than most other varieties in the test.

All the fescues proved satisfactory but tended to go off color during the hot weather. Some fescue has been desirable in most lawn mixes in order to improve the appearance and density of the turf.

Red Top has been recommended as a short-lived filler in mixes where rapid establishment in turfing is desired. We found this practice highly undesirable, especially on heavier-textured soils. The grass proved to be long-lived and very aggressive, often choking out all others. It forms a heavy thatch and was subject to winter injury and die-back, forming unsightly brown and bare patches during the spring.

Organic Matter Test

Southern interior soils are notoriously low in organic matter generally (as well as nitrogen). A test was established to determine if fir sawdust, peat moss, and cow manure plus shavings were all satisfactory as additives. Sawdust was satisfactory provided enough nitrogen was added (generally every three weeks to a month for the first two or three years). The plots of cow manure plus shavings, required less nitrogen but contained more weeds to the point of requiring herbicidal treatment. The weed problem would vary depending on the source of the manure. Peat moss was the most expensive but required less nitrogen and remained relatively weed free. At the end of three years, however, no difference could be seen among any of the plots.

COLONIAL BENTGRASS ON THE WEST COAST

By H. Vaartnou
University of British Columbia

Colonial bentgrass, as a turf species, is one of the lawn grasses best suited to our West Coast climate. Normally, if Colonial bentgrass has been used in a mixture of lawn seed, it forces out of the lawn in a few years the other grasses, such as fescues and Kentucky bluegrass. It becomes the dominant species if the lawn receives the maintenance required by Colonial bentgrass.

At the present time, Colonial bentgrass seed, which is marketed under different trade names depending on the locality harvested, is more or less a mixture of different genotypes. Because of this, it is not unusual to be able to select out of one pound of seed twenty-five or more different genotypes which show a variety of growth habits and form different types of turf.

If you compare the four different genotypes of Colonial bentgrass on display here, you will see that each one produces a different type of turf. It is time we start to think of varieties of Colonial bentgrass which are selected for a specific type of turf, such as for golf greens, bowling greens, playing fields, home lawns and park lands. I believe that there is enough genotypic variation within Colonial bentgrass to satisfy all of these requirements on the West Coast.

Now to consider the question of fertility. How often do we ask ourselves "Why do we fertilize?" Which part of the plant do we want to grow—the leaves or the roots? Do we want to improve the tillering, grow rhizomes and stolons, or do we fertilize to obtain greater winter hardiness and disease resistance. These various growth requirements need a different type of fertilizer program. Fertilizer is applied at different times of the year, depending on the purpose of the application. For example, in summer when we want the leaves to grow, we use mainly nitrogen. The requirements for phosphate and potassium are very low at this time of the year. However, in fall and spring, when we would like plants to produce new roots, to obtain additional winter hardiness and to increase disease resistance, nitrogen is detrimental while phosphate and potassium are required in a higher ratio. The amount of fertilizer to use depends on the local growing conditions, management practices, previous applications and purpose of application.

The topdressing requirements for Colonial bentgrass differ from that of annual bluegrass and creeping bentgrass. These latter grasses, since they are surface rooting types, require topdressing to provide a rooting media, whereas this is not the case for Colonial bentgrass. Topdressing of Colonial bentgrass greens is done for the purpose of levelling the sod. Improving aeration and water absorption. If sand is the material used, it may on certain types of soil, accumulate on the surface and under this condition there is no need to add more sand. Instead, a power-rake or verti-cut is used to loosen the surface, after which the turf is re-levelled.

In the production and maintenance of good turf, Colonial bentgrass ranks as one of the easier grasses to maintain. In view of the great diversity in the nature and properties of soil types, grass species, management practices and the technical knowledge of superintendents, I believe that greater use should be made of Colonial bentgrass.
Talk given to the Turf Convention, Sept. 21-25, 1964.

MOWING, AN ECOLOGICAL FACTOR

J. R. Watson, Jr.[1]

Plant ecology may be defined as the study of the relationship of plants to their environment. Hence, any factor that affects environment or influences growth becomes an ecological factor. Such is the case with mowing. This technique, so necessary to produce a well groomed appearance, is one of the major management practices with which the turfgrass supervisor is concerned. Also, it is one of the factors limiting or controlling the adaptability or suitability of a given grass for turf purposes.

The broad influence of climate (primarily temperature) dictates the adaptability of groups of grasses—cool season versus warm season. Micro climate (as well as macro) along with soil conditions and management practices collectively determine the local environment.

Plant structural features, such as depth of root system, number of root branches, storage tissue and physiological features, such as rate of transpiration, water absorption, rate of shoot growth and photosynthetic efficiency are factors which determine what grass or other plant will survive under the local conditions existing on any given turfgrass area. Every species of plant seems to be fitted to a particular set of environmental circumstances, within the limits of which it is able to grow. Some plants, notably weeds (and in the case of golf greens, Poa annua, in particular) are tolerant of many types of environments.

This discussion of mowing as an ecological factor will be from the standpoint of the limited or restricted environment as found on turfgrass areas.

To be suitable for the production of turf, a grass plant must be able to grow and persist under the environmental conditions to which it is subjected. Good turfgrass is judged by standards of playability and usability, as the case may be, and unless a grass is able to survive or adapt to the type of maintenance demanded by players or users, it must (1) be replaced or (2) maintenance practices must be modified; otherwise, (3) use must be restricted or limited. For those concerned with the production of turfgrass, limiting or restricting use of a playing area should be considered as a last resort. The primary objective of the supervisor is to produce high quality turfgrass suitable for use or play irrespective of environmental adversity.

More often than not, practices which are desirable for good grass growth have to be modified extensively to meet turfgrass requirements for use or play. Such is the case with mowing practices. Height of cut on a putting green may serve to illustrate this point. The reduction in root growth that clipping to a height of 3/16 to 1/4 inch produces is well known—but try and convince a golfer that the green should be cut at a height of 1 to 2 inches! To compensate for the reduction in root growth, all other maintenance practices—fertilizing, watering, cultivating and programs of disease, insect and weed control—must be balanced one against the other and applied more intensively and with greater care.

Management practices, including mowing, must be keyed to the *use* for which the turfgrass area is being produced. Such severely limits the number of grasses that may be used to produce satisfactory turfgrass—only a few (25-30) out of the more than 1,100 species adapted to North America. In view of the limitation that mowing places on selection of grass and intensity of management, it may be well to ask "Why Mow?"

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[1]Director, Agronomy Division, Toro Manufacturing Corporation, Minneapolis, Minnesota.

Why Mow? Appearance and playability are the principle reasons for mowing turfgrass. Unless it is mowed, a turfgrass area would soon become like an overgrown pasture—an area covered with loose growing, spindly grasses and tall, rank weeds which cannot persist under normal mowing practices. The manner in which turfgrass is mowed will greatly influence its health, vigor, density, degree of weed invasion and longevity. In fact, good mowing practices are perhaps the most important factor contributing to a well-groomed appearance and the longevity of any turfgrass area. The development of good mowing practices from an agronomic standpoint must be based on an understanding of growth habits and characteristics of grasses.

Growth Habits and Characteristics

On the basis of growth type, grasses may be classified into three general groups. Bunch type grasses, such as ryegrass and chewings fescue, produce new shoots which grow inside the sheaths of the previous stem growth. Stoloniferous grasses, such as bentgrass, spread by runners or stolons which develop from shoots that push through the sheath and run along the surface of the ground, rooting at the nodes (joints). Kentucky bluegrass, a rhizomatous type of grass, develops shoots at the underground nodes. Some grasses, such as bermudagrass and Zoysia, spread by both rhizomes and stolons. This is one reason why bermudagrass is such a vigorous grower and is so difficult to control and keep out of flower beds, gravel walks and similar areas. There are also intermediate types with decumbent stems which root at the nodes, such as crabgrass and nimblewill.

The grass leaf is remarkably adapted for intercepting a maximum of sun rays which are essential for photosynthesis. The long flattened grass blades provide a maximum of exposure with a minimum amount of protoplasm, thus making efficient use of the living tissue. A reduction in the plant leaf area exposed to sunlight reduces the plant's capacity to carry on photosynthetic activity. This is a vital and basic consideration in determining the frequency and height of cut of turfgrasses.

The ability of grasses to withstand frequent and relatively close cutting is related to certain peculiarities of the grass family. Grasses exhibit basal growth, as opposed to terminal growth found in most other plants. Basal growth means simply that growth initiates at the base rather than at the tip or the blade or stem. From a practical standpoint this means that normal and frequent mowing does not cut off the growing areas of the grass leaf. Removal of too much leaf surface at any one cutting may, however, destroy some of the growing points.

Height of Cut

The height at which a given perennial grass can be cut and still survive for extended periods is directly related to its ability to produce sufficient leaf surface for the photosynthetic activity required for its growth. Basically, this ability is related to the inherent type and habit of growth found in the grass. The length of internodes, the number of stolons or rhizomes, and the number of basal buds all influence the amount of leaf mass produced by a given grass; hence, affects its ability to withstand low heights of cut.

Creeping type plants, such as bentgrass and bermudagrass, when properly fertilized and watered are able to produce adequate leaf surface at very low heights of cut (3/16 inch). Buffalograss, although a creeper, cannot produce sufficient leaf mass at low heights because too few basal buds exist and, therefore, cannot withstand low clipping. For this same reason, Kentucky bluegrass and fescue must be cut relatively high (1-1½ inches). If bunch type grasses are cut close, too much leaf surface is removed and the plant can no longer carry on sufficient photosynthetic activity to sustain satisfactory growth.

Frequency of Cut

Frequency of mowing is also an important consideration in the maintenance program. Infrequent clipping allows the grass to elongate to such a degree that any subsequent clipping removes an excessive amount of leaf surface. At no time should clipping amounts in excess of one-third of the total leaf surface be removed at a given mowing on lawns. Removal of large amounts of leaf surface will produce stubby, unsightly turf, cause excessive graying or browning of the leaf tips, and curtail the photosynthetic production of food with a resultant depletion of root reserves. This is the principle upon which mowing to control weed growth is based.

In addition, the accumulation of excessive clippings may smother the grass and provide excellent environmental conditions for disease organisms and insects. The frequency of clipping must be governed by the amount of growth, which, in turn, is related to weather conditions, season of the year, soil fertility, moisture conditions, and the natural growth rate of the grasses, and—most important—the use for which the area is being grown.

Other Considerations

In addition to the mowing practices related directly to habit of growth, there are other considerations that must be taken into account when developing a sound mowing program.

Stage of growth. The stage of growth of turfgrass plays a major role in mowing practices. Young tender growth in the spring is generally soft and succulent. The moisture content of young, immature turfgrass is much higher than that of mature grass. Likewise, the fiber content of young grass is much lower than that of mature grass. Such a condition influences mowing practices. Tender young grass must be cut with a sharp, well adjusted mower to avoid mechanical damage, and the early growth must be cut frequently to avoid the problem associated with high moisture.

Mowing practices during the early stages of growth exert a material influence on density of turfgrass. Cutting at heights somewhat lower than normal during early spring will encourage lateral growth which, in turn, promotes density and helps prevent weed invasion.

Washboard effect. Turfgrass areas regularly cut with power mowers or gang mowers sometimes develop a series of wave-like ridges running at right angles to the direction of mowing. **If such is not caused by too wide a frequency of clip,** it may be prevented or partially remedied by regular changing of the direction of mowing (diagonal or right angles). Alternate directions of cut will partially control runners of creeping grasses and aid in the prevention of grain and thatch. If clip is responsible. the height of cut must be raised or the mower replaced with a unit having more blades or a faster reel speed.

A very similar washboard appearance is often observed on turf areas, but is no fault of the mowing equipment or the operator. Many times land is plowed for seedbed preparation and not properly disked and leveled prior to seeding. Settling then takes place in the plow furrows and unevenness develops. Such a situation may be reduced in severity over a period of years by heavy aeration followed by dragging. The dragging operation generally will remove most of the soil cores from the high areas and deposit them in the low areas.

Wet conditions. Mowing wet grass should be avoided as much as possible, although available labor and time often make it impractical to do so. Dry grass cuts more easily, does not ball up and clog the mower, and gives a much finer appearing lawn. Timing tests show that mowing dry grass requires less time than mowing wet grass.

Uneven terrain. Mowers are not built for grading purposes. Turf areas containing high areas which are continually scalped should be regraded in order that they may be cut properly and to reduce the wear and possible damage to mowing equipment.

Inadequate insect control can become a serious mowing problem. Areas heavily infested with earthworms or ants may have many soil mounds caused by their activity. Such may cause soil to build up on rollers, or in severe cases simply cause the units to bounce, both cases resulted in an uneven cut. Mounds of earth thrown up by gophers and other soil burrowing animals will have the same result.

Improper operation. Irregular or uneven cutting often occurs due to bouncing of the mowing units when they are pulled at excessive speeds. On specialized areas such as putting greens, bowling greens, lawn tennis, etc., improper handling of the mower on turns will result in turf damage through bruising and wearing of the grass.

Terraces and banks. Terraces and banks offer a difficult mowing problem. Scalping generally will occur if the bank or terrace is mowed across the slope. Up and down mowing generally is the most satisfactory method of cutting these areas.

SUMMARY

Mowing is not a simple operation to be regarded as merely a means of removing excess growth. Mowing is an ecological factor because mowing practices influence the species and strain of turfgrass being grown. The inherent physiological, anotomical and morphological characteristics of a given grass will determine the height and frequency of mowing that will give the most satisfactory performance. Mowing is the most time-consuming of all management practices and has far reaching effects on the appearance and longevity of any turfgrass area.

Prepared for: Northwest Turfgrass Conference, September, 1964.

IRRIGATION NEEDS OF SPORTSGRASS TURF

R. H. Turley
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I would like to discuss turf irrigation under three phases: Some methods of determining irrigation requirements; the effect of various soils on irrigation requirements; and some remarks on when and how much to irrigate.

At the Saanichton Experiment Farm we have three methods of determining irrigation requirements. The first is by taking actual soil samples, weighing and drying them and determining the actual percentage moisture in the soil. This perhaps should not be called a method of determining irrigation requirements as it is impractical from a cost standpoint and tedious to perform. It does, however, give us an accurate measurement of the percent moisture in the soil and allows us to correlate empirical methods with soil moisture. The second, electrical resistance readings, has been used for many years at the Saanichton Farm for determining when and how much to irrigate. This method consists of burying electrodes embedded in plaster of Paris blocks, in the soil at various depths and reading the resistance to an electric current on a modified Wheatstone bridge ohm meter. As the soil becomes drier, the resistance to the current increases causing a higher reading on the meter. Under pasture work we irrigate when the meter reading at the 6-inch depth block is 10,000 to 12,000 ohms. Irrigation is continued until the reading at the 24-inch depth block starts to fall. This method has been highly successful for irrigating pasture but not too good for lawns. Lower meter readings, probably 6,000 to 8,000 ohms, would be better for irrigating lawns.

The third method, and the one we like for determining irrigation applications on lawns, is based on evaporation readings as determined by the black Bellani plate atmometer, a model of which is on display. As you can see the atmometer consists of a porous china evaporation cup attached to a sealing tube equipped with a one-way mercury valve and then attached by a hose to a 250 ml reservoir. The amount of water evaporated from the porous plate can be determined by reading the scale on the reservoir.

So much for the methods of determining evaporation! Let us consider how we can use this data as a guide for irrigating fine turf. Temperature, sunlight, wind and humidity are the factors which determine the rate of evaporation. These same climatic factors also determine the rate at which plants use or transpire water. The possibility of using evaporation data for predicting irrigation requirements is dependent upon the principle that the rate of evaporation of water from soil completely covered by growing vegetation cannot exceed a well defined maximum, no matter how much water is available. The maximum rate depends almost entirely on the meteorological conditions and very little on the nature of the vegetation as long as it is in a green growing state and completely covers the soil. Therefore if we replace this water loss from the soil, optimum moisture conditions for plant growth will prevail.

Evaporimeters of various types are widely used to estimate potential evapotranspiration (total possible evaporation from soil and plants). The U.S.A. class A weather pan is widely used on this continent. We like the black Bellani plate and have found it to be very responsive to climatic conditions, accurate and easy to use. The advantage of the black Bellani plate over the class A weather pan is that it is less expensive, smaller and easier to install in out-of-the-way places.

I would like to outline the procedure used for determining when and how to irrigate based on meteorological data. The following observations of weather factors are required:

(a) Rainfall measured daily using a standard rain gauge.
(b) Latent evaporation measured at the same time as the rainfall. At our Farm we determine latent evaporation using the black Bellani plate.

These data, that is daily rainfall and latent evaporation, are entered on a soil moisture budget form (see Sheet 1 of hand-out). It is recommended that two instruments be maintained to act as a check on each other. When they don't read approximately the same, discard the low reading plate and install a new one. The average scale reading of both instruments are entered on the sheet and the amount of water used is the difference between the previous day's reading. The daily latent evaporation in c.c. is multiplied by the conversion factor .0034 to convert it to inches of water used by crops. The water used by crops plus the accumulated deficit from previous day minus the rainfall is entered in the column "Soil moisture deficit before irrigation". The irrigation schedule you have before you is based on a 1-inch deficit; in other words, each time the soil moisture deficit reaches 1 inch or more, you apply an inch of irrigation. This returns the soil moisture to field capacity and the cycle starts over again to determine the next date of irrigation. There is one thing to note—where rainfall is heavy, leaving a surplus over and above the soil moisture deficit, the surplus is lost. The soil has been returned to field capacity and the surplus will be lost to the plants by deep percolation.

This tells you when to irrigate but how do you determine how much to apply per irrigation? To do a good job of irrigating you must consider the rooting habits of grasses. You all know that grasses develop surprisingly extensive root systems of great depths. However, what is the *effective rooting depth?* Dr. Robert M. Hagan of the University of California lists the following effective rooting depth in inches (1952 Southern Calif. Turf Conference):

Chewings fescue	8 inches
Illahee and F-74 fescue	10 inches
Highland bentgrass	12 inches
Kentucky & Merion bluegrass	30-36 inches

Our lawn irrigation work at Saanichton confirms Dr. Hagan's conclusions. The turfs of Chewings fescue, Highland bentgrass and Merion bluegrass were showing signs of drying out before soil moisture was removed from the 15-inch depth. Let us consider a cubic foot of soil as a water storage reservoir, one foot being the approximate effective rooting depth of most lawn turf in the northwest area. The amount of water available to the turf is the difference between the field capacity of the soil and wilting point. The available water in our reservoir will vary with the type of soil. Again referring to Dr. Hagen, he states that sandy soils will hold ½ to ¾ inch of available water per foot of depth, loams about 1½ inches, and clays about 2½ inches. In theory all you have to do is replace your soil moisture when your atmometer indicates you are approaching the wilting point of your particular soil. I will very briefly give you the results of an irrigated turf experiment conducted at Saanichton in 1962 and 1963. Plots consisting of pure stands of Chewings fescue, Highland bent and Merion blue grasses were irrigated when the soil moisture as determined by the black Bellani plate atmometer reached a deficit on ½, ¾, 1 and 1¼ inches. All the plots received the same amount of total water over the season; only the interval between treatments varied. For example, the plot receiving ½ inch of water was irrigated twice as frequently as the plot receiving 1 inch of water. Two complete sets of plots were maintained. One set was located on a heavy clay soil and one on a light sandy loam. Now if you will turn to the second sheet of the hand-out you will see some of the results of this project in tabular form. Actually there was relatively little difference in dry matter yield and in turf quality between the different irrigation treatments.

The only really noticeable lack of moisture on the turf occurred on the 1¼ inch irrigation treatment on the sandy soil for a short period in August 1963. This was the driest part of the entire 1963 season. Now if you will examine Table 3, the influence of irrigation treatments on the percent moisture in the soil, you will see that the lighter irrigation treatments maintained a higher soil moisture over the season. This was especially true in the light sandy soil. You will see from the graph at the bottom of the page that the frequent light irrigations maintained superior soil moisture throughout the whole season compared to the heavier less frequent treatments. This experiment shows quite clearly that light frequent irrigations maintain better soil moisture; but what is a practical application? This of course varies with the soil type but for a general recommendation, a 1-inch application of water should be about right for fairways. On greens, where you are trying for perfection, a ½" to ¾" application of water would be recommended.

Now just to sum up . . . you can determine WHEN to irrigate using meteorological equipment which records evaporation. In Canada, we recommend the black Bellani plate atmometer. In U.S.A., the U.S. Weather Bureau make daily reports of evaporation data which can be used to establish your own soil moisture budget. The Washington State University, Extension Service, Pullman, Wash., have an Irrigation Scheduling Board and Record for recording evaporation data. Simply ask for Circular 341 including the form and full instructions. Irrigation requirements vary for each soil type, sandy soils holding a minimum of ½" to clay soils holding 2½ inches of water. The water lost by the soil should be replaced by an irrigation application before the wilting point of the turf has been reached. By experience we have found a 1-inch application of water per irrigation meets most lawn requirements. On very sandy soils and for very high quality turf, we recommend that the rate of application be reduced and the frequency of application of water be increased.

RECORD OF DAILY LATENT EVAPORATION AND CALCULATED SOIL MOISTURE BUDGET

Station Saanichton, C.D.A. Province B.C., Month July, Year 1964.

Date	Instrument No. 1 Coefficient 0.89 Scale reading	Instrument No. 1 Coefficient 0.89 Water used	Instrument No. 2 Coefficient 0.89 Scale reading	Instrument No. 2 Coefficient 0.89 Water used	Daily L.E. c.c	Water used by crop L.E. x 0.0034	Soil Moisture budget calculation: Rain	Irri.	Soil Moisture Deficit Before irrigation	Soil Moisture Deficit After irrigation	Soil Moisture Surplus
						ins.	ins.	ins.	ins.	ins.	ins.
1	207	41	206	41	36.49	.0545			.6864		
2	235-0	28	234-0	28	24.92	.1241	Tr.		.5472		
3	18	18	18	18	16.02	.0847			.6319		
4	54	36	54	36	32.04	.1089			.7953		
5	84	30	86	32	27.59	.0938			.8891		
6	101	17	102	16	14.68	.0499	Tr.		.9390		
7	125	24	127	25	21.80	.0741	Tr.	1.00	1.0131	.0131	
8	126	1	129	2	1.33	.0045	0.14				.1224
9	161	35	165	36	31.59	.1074	Tr.		.1074		
10	195-0	34	201-0	36	31.15	.1059			.2133		
11	40	40	39	39	35.15	.1195			.3328		
12	79	39	78	39	34.71	.1180			.4508		
13	126	47	127	49	42.72	.1452	0.26		.3360		
14	127	1	128	1	0.89	.0030	0.17		.1690		
15	129	2	130	2	1.78	.0061	0.23				.0549
16	135	6	136	6	5.34	.0182	0.13				.1118
17	164	29	167	31	26.70	.0908			.0908		
18	190	26	194	27	23.58	.0802			.1710		
19	220-0	30	224-0	30	26.70	.0908	0.03		.2318		
20	5	5	5	5	4.90	.0167	0.26				.0115
21	20	15	20	15	14.70	.0500	Tr.		.0500		
22	35	15	36	16	15.19	.0516	0.08		.0216		
23	68	33	70	34	29.81	.1014			.1230		
24	98	30	99	29	26.25	.0893			.2123		
25	128	30	130	31	27.14	.0923			.3046		
26	165	37	170	40	34.26	.1165			.4211		
27	203-0	38	209-0	39	34.26	.1165			.5376		
28	36	36	38	38	32.93	.1120			.6496		
29	67	31	69	31	27.59	.0938			.7434		
30	79	12	81	12	10.68	.0363	0.04		.7397		
31	100	21	103	22	19.13	.0650			.8047		
		Total					1.34				

The influence of irrigation treatments on total dry matter yield of clippings. Grams per plot.

Irrigation treatments	1962 Clay loam	1962 Sandy loam	1963 Clay loam	1963 Sandy loam
½ inch	690	575	1308	1128
¾ inch	609	502	1286	1188
1 inch	660	482	1243	1047
1¼ inches	681	484	1215	998
L.S.D.	44	N.S.	N.S.	91
C of V.	2.3	3.9	2.5	2.3

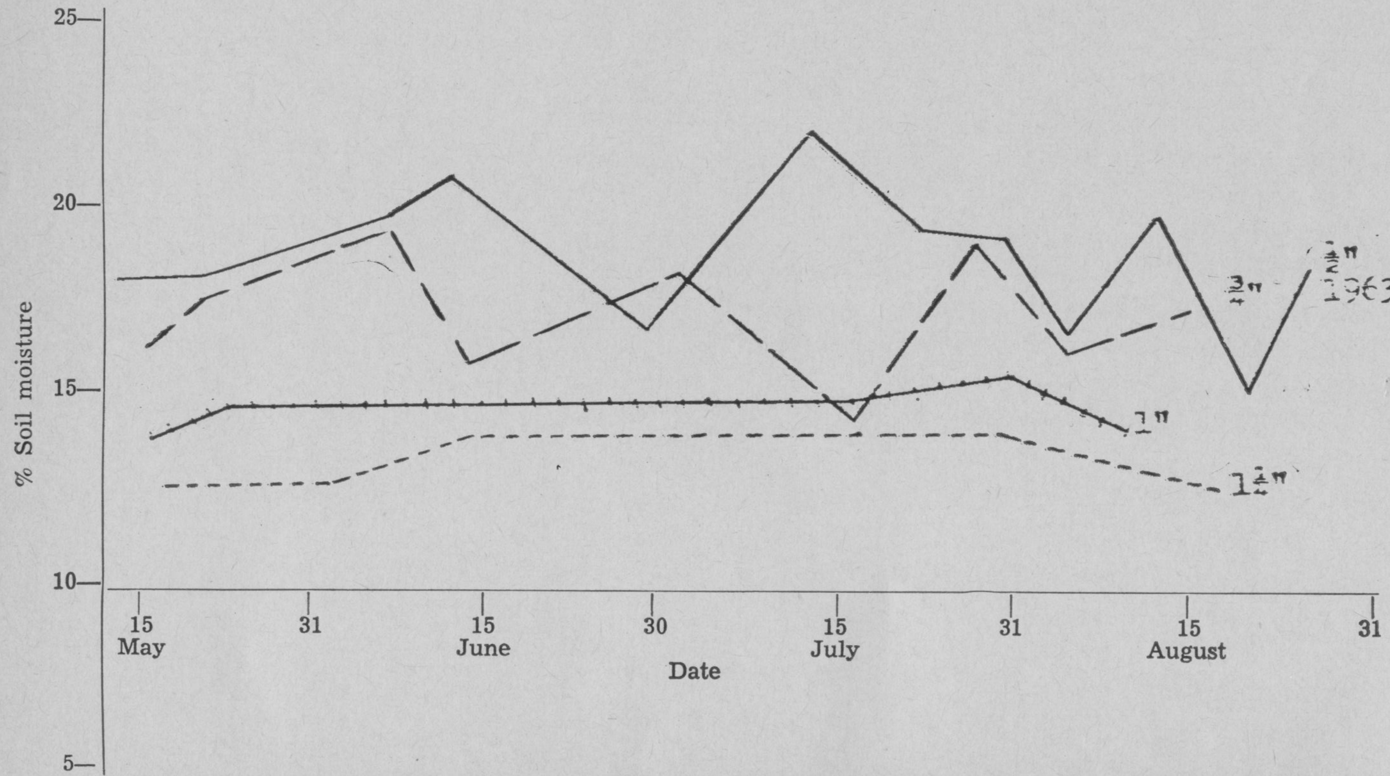
The influence of irrigation treatments on visual turf quality ratings*

Irrigation treatments	1962 Clay loam	1962 Sandy loam	1963 Clay loam	1963 Sandy loam
½ inch	7.50	7.33	7.58	7.92
¾ inch	6.42	6.17	7.50	7.86
1 inch	6.83	6.50	7.75	7.79
1¼ inches	7.17	6.91	7.66	7.15

*Turf quality rated 1-10, with 10 highest

The influence of irrigation treatments on the mean percentage of moisture in the soil from 0-12 inch depth.

Irrigation treatments	1962 Clay loam	1962 Sandy loam	1963 Clay loam	1963 Sandy loam
½ inch	13.66	12.02	18.00	13.02
¾ inch	14.90	7.13	16.44	11.32
1 inch	12.71	6.97	14.22	9.88
1¼ inches	12.46	6.67	13.63	9.55
L.S.D.	N.S.	2.22	3.11	1.71
C. of V.	5.58	8.26	6.24	4.80



Percent moisture in clay loam prior to irrigations.
1963

TRENDS IN GOLF ARCHITECTURE

W. H. Bengeyfield
USGA Green Section, P.O. Box 567, Garden Grove, Calif.

Perhaps the most misused term in golf is the word "green". How often have you heard someone incorrectly refer to the Greens Superintendent, Greens Chairman or even the RCGA or USGA Greens Section? Actually, the word "greens" is concerned only with the putting green on a golf course. The term "green" refers to the whole golf course. "Through the green" is that area from the tee to the green itself, excluding the bunkers. Therefore, the correct terminology is Green Superintendent, Green Chairman and Green Section.

This leads nicely into our topic of "Trends in Golf Architecture". I'm sure the Royal Canadian Golf Association and the USGA Green Section is concerned with everything that takes place "through the green" and this includes golf architecture as well.

The USGA is becoming seriously concerned with a disturbing trend in golf architecture today. At a time when golf courses are being built so rapidly, it is inevitable that many incompetents and unqualified individuals will become active in the business of golf course design. After all, anyone who considers himself a fair golfer, a fair turfgrass man or has some type of artistic sense—might well believe that he is also a qualified golf course architect.

I can cite dozens of examples where the architect through haste, through lack of supervision, through lack of knowledge, through indifference, and in some cases through greed, has left a golf club with built in problems which will surely show up at a later date. In many cases, the golf course superintendent is blamed for lack of maintenance skill when the difficulty develops. We are concerned because the architect's clients later become USGA members. Surely the future will hold a great interest on our part in the area of golf architecture.

Let me cite an outstanding example of this dangerous trend in golf course building today. This past summer a feature article on a "young and promising golf course architect" appeared in one of the major newspapers in Texas. During the interview, the featured golf architect was asked, "How much formal education does it take to become a golf course architect?"

"None," replied the young man, "If you know enough bull-dozer operators. It just takes practical knowledge."

This is indicative of the attitudes of many of those who call themselves architects today. The statement about an architect needing no education unfortunately reflects the thinking of many people in business. Furthermore, this feeling is propagated by architects who are regarded as capable and well trained, but who all too often do not offer much of a target of excellence for the novices to shoot for.

If I had been called on to give this talk a few years ago, I'm afraid it would have been almost entirely 'anti-architect'. Today however, the story is different. I have found it is far easier to criticize an architect than it is to expose yourself to the actual problem of golf course design and construction. This is not easy work—if it is to be done correctly.

A few years ago I was visiting with a noted western golf course architect. When asked why so many poor courses, both in design and construction, were being built today, he had an enlightening answer:

"You have a client or a prospective one. He has 130 acres and he wants you to design a championship 18-hole layout that is 7,000 yards long. He then wants you to design it around 80 home building sites on the property, a clubhouse with adequate parking, roads, a driving range, a lake and some service facilities as well. And he wants the course built for $200,000 including an automatic irrigation system!

"Of course, it can't be done but if I don't take the job, someone else will and I've got just as much interest in economics as the next person."

Sometimes, we just don't undertand or expose ourselves to other fellows viewpoint. He has to make a living too and the client gets just about what he pays for. So let's be honest about it: Even the well trained and well known people in the business frequently do jobs very poorly. After all, you cannot build a cheap palace.

Some other examples of this trend in design may interest you. The following are true stories:

Within the past year, a fairly new course was chosen for a major tournament in 1965. The designer is a student of the game and highly respected. Yet, somewhere along the line, there was a failure in engineering with respect to a small creek running through the property. Consequently, ever since the course has been opened, the maintenance crew has been involved in raising greens, raising fairways and creating new drainage ways to the creek. All this in an effort to keep silt off of the low fairways and greens. It's a great golf course—if it doesn't rain!

Each year the USGA Green Section receives a number of "trouble calls" due to built in problems. For example, we have experienced the following situations in the past year:

1. Two trouble calls relating to putting green soils and poor drainage.
2. One trouble call concerned with a poorly designed irrigation layout that has just been completed.
3. One trouble call from a new course where a few greens were built in a pocketed area.
4. A serious problem with trap or bunker drainage. Adequate drainage was not provided by the architect.

All of these from new courses that are less than five years old.

Marvin Ferguson of the USGA Green Section tells of this true experience in the recent past. One of the clubs he visits decided to redesign a hole on their course. The tee did not come out quite right. Upon inquiring, he learned that the architect had left the job after telling the bull-dozer operator to "go over on the side of that hill by the oak tree and shape up a tee." The bull-dozer operator went to the golf course superintendent, after the architect had left, and asked, "What's a tee?"

Two years ago I experienced an "architectural problem" on a new course in the west. The 'architect' was retained to lay out 18 holes. He placed the center stakes marking the first tee, the first fairway, the first green and so on around the course. Before earth moving was started, the course representatives took a tour of the area with him. The first hole was supposed to measure somewhere near 500 yards. It looked a bit long to one of the officials and he later returned to measure it for himself. It turned out to be over 650 yards long!

So it seems we are constantly second guessing and trying to correct the mistakes made by some so-called golf course architects. Something must be done and, thankfully steps are being taken. The American Society of Golf Course Architects, the National Golf Foundation and interested Golf Associations are becoming directly concerned with the problem.

What makes a good golf course? It's a hard thing to define, yet anyone who plays golf at all has a definite liking for certain courses. They are fun to play, they are interesting, they are challenging and they are beautiful.

It's the job of architects to discover and utilize every feature of a piece of property or to manufacture features that will make a course interesting and appealing. A noted architect once said, "The ideal course should demand alertness of mind as well as playing skill. If it does not, the player never senses the enjoyment in meeting the series of tests and challenges a golf course should offer."

"Trends in Golf Architecture" is such a tremendous subject that we could dwell on for an entire month, perhaps a year. There are certain references available from the USGA and, should you be interested, we would be happy to send them to you. For the purposes of this discussion however, let us summarize by saying that one of the major trends in golf architecture today is toward mediocrity in the principles of construction and design. It is a trend that can—yes, must be checked.

EFFECTS OF ENVIRONMENT AND OPHIOBOLUS ON THE COMPOSITION OF TURF

Charles J. Gould*

Ecology has been defined as the study of mutual relations among organisms and their environment. Insofar as turf is concerned, one of the main environmental factors consists of microorganisms. The inocuous and benficial organisms usually outnumber and suppress the parasitic ones, although the latter frequently get the upper hand. When this occurs, turfgrasses are weakened and/or destroyed. Then the way is paved for such weeds as annual bluegrass (*Poa annua*), chickweed (*Stellaria and Cerastium spp.*), pearlwort (*Sagina* sp.), dandelion (*Taraxcum officinale*), and clover (*Trifolium sp.*) to take over.

The importance of annual bluegress in the Northwest has been demonstrated by the amount of time devoted to it in the opening session of this Conference. It is the predominant grass on most greens in the Pacific Northwest, although only bentgrass (*Agrostis* spp.) was originally planted. Annual bluegrass is also a major component of other types of turf in this region. What has brought about this shift from bent to annual bluegrass? For several years some of us have believed that diseases can be blamed for much of the invasion by various weeds. Now we are beginning to get some concrete evidence. Let's consider some recent data from plots on which Roy Goss, Vern Miller and I are testing fungicides. Sod of Colonial Bent was laid in these plots at our experiment station at Puyallup in the fall of 1961. Fungicidal applications were begun in the spring of 1962 and continued at 3 week intervals except during the dry summer and cold winter months. On September 11, 1964, Dr. Goss estimated the percentage of bent in the untreated plots at 41% as contrasted with 81% in the plots with the best fungicidal treatment. We believe that most of this decrease of 59% in bent in two years was caused by parasitic fungi, particularly *Fusarium nivale*.

At the rate the bent is disappearing only traces would likely remain if the check plots were left untreated for another two years. Bent is very susceptible to Fusarium. The diseased areas have been invaded mostly by annual bluegrass and pearlwort. Some strains of annual blue-

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grass are susceptible to *Fusarium,* while some appear to be resistant—but all strains apparently are capable of very rapid reinvasion of the dead or thinned areas. Pearlwort is apparently resistant to this fungus.

Bent is also killed or weakened by *Fusarium* in higher cut turf of fairways, lawns and parks. These areas are then invaded by annual bluegrass, chickweed, and clover, and by increased growth of fuscue (*Festuca* sp.), if the latter was present in the original mixture.

Bents may be attacked by other fungi, including *Ophiobolus graminis* var. *avenae,* which we now consider to be a major disease of highcut turf in the Northwest. This fungus has been reported from British Columbia and California, samples have been received from Oregon, and we have observed it in eastern Washington. The disease is very widespread in western Washington but is often overlooked in high-cut turf since other grasses and weeds fill in spots where bent is killed by the fungus. This 'new' disease has been here for a long time probably, but it wasn't recognized before 1960. However, it is also possible that general shifts in such cultural practices as fertilization and liming have encouraged its development. Because Ophiobolus Patch now appears to be of major importance and because we haven't discussed it in detail at previous conferences, it is appropriate to use it as an example in demonstrating both the importance of a fungus parasite as an ecologic factor affecting turfgrasses and the effect of environment on parasites. Some of the following comments on *Ophiobolus* concern its attack on wheat, when comparable data for turfgrasses are not available. On wheat and other cereals the disease is worldwide and is called "Take-All."

OPHIOBOLUS PATCH

Symptoms

On putting green turf the disease at first resembles Fusarium Patch in the development of a small brown dead area, but even at this stage there are some differences. An active Ophiobolus patch is often bright brown, or bleached, or sometimes has a reddish tinge as contrasted to the dull brown, greenish-brown, or blackish-brown color of Fusarium Patch. In addition, as it grows, *Ophiobolus* kills the roots and crown so the plants can be easily pulled up, whereas *Fusarium* initially kills only the tops. Prolonged attacks by *Fusarium* may result in eventual death of the roots. *Fusarium* sometimes affects an area up to 6″ wide, but this is unusual on putting greens and the original grass or annual bluegrass normally refills the centers of such spots quickly. The *Ophiobolus* fungus, however, usually continues spreading in an ever-increasing circle, killing the bent and often annual bluegrass as it grows. It spreads most rapidly at warm temperatures. In a small scale test at the Western Washington Experiment Station we placed naturally diseased turf (a mixture of Colonial bent and annual bluegrass) in illuminated growth chambers at different constant temperatures. Under these conditions the fungus spread (or at least the symptoms developed) at a rate of 4″ a month at 51° as compared with a spread of 18″ a month at 77°. Under normal outdoor conditions in western Washington the circles usually increase about six inches in diameter a year.

The fungus also spreads in a circular pattern in fairway or lawn-type turf, killing the bent as it grows. However, the dead areas or circles in such turf are not usually as noticeable as they are in putting greens, since resistant fescues and partially resistant annual bluegrasses are usually present and remain essentially undamaged or quickly invade the open areas. Consequently, the infected area is thinned but is seldom completely bare. But the thinning does open the way for invasion by annual bluegrass and other weeds.

Hosts

Bentgrasses are very susceptible but fescues are resistant to *Ophiobolus* under our conditions. Reports indicate that the reverse may be true in other areas. It must be remembered, however, that different strains of this fungus exist which may differ in their preference of hosts. The only strain that we have identified in our turf is apparently the type that also attacks oats (*Ophiobolus graminis* Sacc var. *avenae* E. M. Turner). Annual bluegrass is reported to be somewhat susceptible to this *Ophiobolus*, but other species of bluegrasses are less susceptible.

Infection

Most *Ophiobolus* is probably spread by transportation of diseased leaves and stems on mowing machines. This movement, of course, could occur at any time of the year. However, the fungus may also be spread by ascospores (which function as "seeds") that develop in late fall in small black flask-shaped bodies (perithecia) on the base of grass stems or on roots. As soon as the fungus becomes established in a plant it can spread from plant to plant by growing along the roots. It apparently does not grow very far through the soil in the absence of grass or other susceptible roots.

New infections in turf usually appear in late spring, enlarge rapidly in the summer if moisture is adequate, and continue enlarging slowly during the fall. The spots remain relatively quiescent during the coldest part of the winter and during dry summers. Margins of the advancing rings are usually 1-3 inches wide and bright brown in color when the fungus is actively spreading. Later the dead areas become dull brown or bleached and during the winter turn light grey as the dead grass becomes matted. Partially-infected plants may remain green or light-green during cool moist periods in the spring or summer but turn brown in a few hours or days during hot dry weather which puts the plants under a heavy water stress.

Factors Affecting Infection

Soil Type—Attacks on wheat have occurred in many different types of soils, but they are usually most severe on light sandy ones (2). The fungus can attack in heavy soils if other conditions are optimal for the pathogen. We haven't studied this factor yet but assume that the response of turfgrasses would be similar.

Moisture—Heavy attacks on wheat have occurred in both Europe and the United States following unusually wet periods. Sprague (10) reported that the Take-All disease on wheat was very severe in the Pacific Northwest in 1948—a year of heavy rainfall in the spring and early summer. Reports from England also indicate that Ophiobolus Patch is most severe on turfgrasses following unusually wet periods. The fungus is suppressed, however, in excessively wet soils where aeration is poor. In such cases a high carbon dioxide content of air in the soil apparently retards growth of the fungus along roots (2).

Temperature—The fungus grows most rapidly in culture at 73 to 75° F, but most crown infection of wheat occurs at temperatures of 54 to 61° F (2). Observations in western Washington indicate that *Ophiobolus* spreads most rapidly under warm conditions, if the moisture supply is adequate.

Nutrition—*Ophiobolus* attacks wheat most often in soils in which the nutrition is low or unbalanced (2). Likewise, the disease has been noticed most often in grass which suffers from malnutrition, such as unfertilized fairways. However, a high level of nitrogen has increased disease loss in wheat if the nitrogen was unbalanced in relation to phosphorus. On infested soils low in phosphorus but optimum for nitrogen the disease losses in wheat have been reduced in proportion to the amount of phosphorus added. Garrett (2) has shown that addition of nitrogen often gives control in wheat during the current growing season, apparently because roots develop faster than the fungus. However, if sufficient food is available for fungus survival, attack on the subsequent crop may be greater than if no nitrogen were used.

Because turfgrasses are perennial, their nutrition is complicated, and procedures that might work for wheat will not necessarily work for turf. Relatively high rates of nitrogen are required for good growth of grasses. The age of turf also appears to be a complicating factor. In cooperative tests with Dr. Goss on plots planted in 1959 the disease was first noticed in June, 1960. By January, 1961, it was slightly less on low nitrogen and low potash plots than on other plots. By September, 1961, the low nitrogen plots were definitely superior to the high nitrogen plots. However, counts made on September 21, 1964 indicate that the effect of nitrogen has become less important and that the relative beneficial influence of both phosphorus and potash has increased as the turf has become older.

pH—The disease most often occurs on wheat grown in alkaline soils (2). Smith (9) reports that in England the fungus usually affects turfgrasses under neutral or near-neutral conditions. His observations and tests indicate that a pH of 5 is about the breaking point and any pH above 5.5 is dangerous. The upper ½ or 1" is apparently the crucial zone. In long term fertilizer experiments at the Sports Turf Research Institute in England, the disease occurred on all plots treated with calcium nitrate or sodium nitrate as the sole source of nitrogen. These materials made the soil less acid, whereas both ammonium sulfate and ammonium phosphate made the soil more acid and less disease was present.

Smith has stated (9) that the disease does not always follow liming. When fungus attack does occur after liming, it may take 1 to 3 years for the onset of severe symptoms and these begin to decline within 2 to 3 years. Symptoms may disappear suddenly (9). The disease has also been seen, although in mild form, where no lime or fertilizers have been applied for ten years (8). Disease losses increased as the particle size of lime decreased in Smith's tests. He recommended that if lime is needed, it should be of a slowly dissolving type (either large grains or other slowly dissolving types), and applied uniformly at an exact rate. The action of lime may be one of absorbing carbon dioxide, the absence of which permits the runner hyphae of the fungus to spread more rapidly along roots (9).

Organic Matter and Soil Microorganisms—The *Ophiobolus* strain that attacks wheat is a poor saprophyte and must have susceptible roots or stems in order to survive. Without such food it perishes in a few months so that rotation is an effective means of control. Presumably the same would be true of turf, but we can seldom rotate turfgrasses. Therefore, we must seek other approaches. Clark (1) has reported that such organic substances as fresh chicken manure and alfalfa tops have given excellent control of the disease in wheat. In view of this it would probably be worthwhile to test such a material as sewage sludge to see if similar results might be obtained on turf.

The action of the chicken manure and alfalfa mentioned above may be due to: increased nutrition (an increase in nitrate nitrogen and available phosphorus was reported); an increase in carbon dioxide which inhibits growth of the fungus along roots; antagonistic microbial action; or, most likely, to a combination of these factors.

Ludwig (6), Garrett (2) and others have shown that many microorganisms in the soil can compete with or antagonize the *Ophiobolus* fungus. One of the most common of these is *Trichoderma viride* which shows similar action against many other soil-borne parasites. When such beneficial organisms are eliminated, as by fumigation of soil with methyl bromide, attacks of turfgrasses by *Ophiobolus* often increase.

CONTROL

Based upon reports in the literature plus our observations and experience in western Washington, the following points are suggested as guides in attempts to control this fungus.

Moisture—Although nothing can be done to control rainfall, adequate drainage should be provided. Irrigation should also be adequate but not excessive.

Nutrition—A well balanced program must be followed. Nitrogen should be adequate but not excessive. Avoid letting the available phosphorus level drop. Include potash to provide resistance to *Fusarium* and perhaps *Ophiobolus*. Ammonium sulfate has been given good control of *Ophiobolus* in our tests in Washington to date and has been reported effective in England and in Australia. Ammonium phosphate has also provided good control in the two latter countries.

pH—Apply lime cautiously. For the best *Ophiobolus* control, keep the pH below 5.5 and preferably around 5 if the turf is severely infected. Use acidifying fertilizers (such as ammonium sulfate), if necessary. If lime applications must be made, use slowly dissolving types. Apply lime uniformly and exactly at the rate recommended on the basis of a soil analysis.

Organic matter—Keep its level high. One reason why the disease is more severe on many fairways than on most other turf areas may be because recently planted fairways are usually low in organic material, while old fairways are often undernourished and unbalanced in nutrition.

Insecticides—*Ophiobolus* was reduced on wheat in England by chlorinated hydrocarbons at 18 lbs. active per acre with heptachlor being most effective followed by aldrin, dieldrin and chlordane, which was toxic (7). Similar results were obtained in Europe at 89 lbs. per acre with chlordane, aldrin, and lindane (4). Chlordane appears promising on turf in tests underway at the Western Washington Experiment Station.

Fungicides—Some of the organic mercuries were partially effective on turf in England (5, 9) and phenyl mercuric acetate has been partially effective in Washington (3). Recent results at the Western Washington Experiment Station indicate that a very finely-ground mixture of mercurous and mercuric chloride (Caloclor is being used in our tests) may be superior to phenyl mercuric acetate.

Conclusions

Because of the many factors involved, it is unlikely that there will be any simple solution to this widespread and destructive disease. The more we study any turfgrass disease, the more complicated we find it to be—with constantly changing interactions between the hosts and environmental or ecological factors. We have just begun to scratch the surface in understanding these. We hope to find time to scratch deeper in the years to come. My thanks to the Northwest Turf Assoc. and Oregon Turf Managers Assoc. whose dollars are helping us do some of this scratching.

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AMINO ACID NUTRITION AND TURF FUNGI

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A recent report by C. J. Gould entitled "Turf-Grass Disease Problems in North America" indicates that there are a number of diseases affecting turf in North America. The report also indicates that some diseases affect turf in all turf growing areas of North America, i.e., some diseases are common to all parts of North America. However, it would appear that these common diseases that appear in all turf growing areas of North America may be very important in one area and relatively unimportant in another area. The report also shows that some diseases occur in some areas but not at all in other areas.

There are a number of reasons for the presence or absence of a disease as there are a number of reasons for the severity of the disease. Grass species show varying degrees of resistance or susceptibility to organisms causing disease. The degree of resistance or susceptibility may be controlled by the genes and is therefore genetic in nature, and is usually inherited. The degree of resistance or susceptibility may also be affected by the environment. Such factors in the environment as moisture, temperature, soil pH, light, and CO_2 content may determine the severity of a disease or even determine whether that disease will occur or not.

One factor of the envionment that has a direct as well as an indirect bearing on the incidence and severity of a disease is the nutritional factor. Organisms as well as the hosts they attack are affected by the kinds and amounts of nutrients present. We in plant pathology at the University of British Columbia are interested in the nutritional requirements of fungi and it is on one phase of this work that I would like to report today. It should be noted that the work we have done has been done in the laboratory only and with only pure cultures of the fungi involved.

Before discussing some of the results of our work I would like to mention some of the factors affecting nutrition of fungi and, in particular, the nutrition of soil fungi.

As I have mentioned the results that will be reported are the results of laboratory experiments with pure cultures of fungi. However, as Garrett in his text "Soil Fungi and Soil Fertility" mentions, "such studies of single organisms in pure culture are an obvious and essential prerequisite for understanding their behaviour in the complex microbial community of the soil. But although this is an essential first step to understanding, it is a first step only; micro-organisms may behave only one way in pure culture, and in another way in a mixed community in which factors of association and competition come into play". Other speakers on this program have referred to ecology as that branch of biology that is concerned with the study of mixed communities of organisms in relation to the habitat in which they live. It is with fungi and their habitats that we will be concerned.

Plant Pathologists usually refer to the habitat or place of growth as the substrate. In the laboratory the substrate is more commonly referred to as the medium upon which the organisms grow. Professor Lilly of West Virginia University lists some of the problems that arise when a fungus is cultivated and studied in the laboratory. "What medium should be used, natural, synthetic, semisynthetic, liquid or solid agar? What carbon and nitrogen sources should be used, and at what concentration? Should vitamins be added? Will the pH of the medium be critical, and how can it be maintained at desired levels? Should media be sterilized by autoclaving, or filtration, or by the use of a fumigant such as propylene oxide? How can maximum sporulation be obtained or how can certain species and isolates be induced to sporulate? How should growth and sporulation be measured? Should the cultures be grown in light or darkness or alternating light and darkness? What temperature should be used? How much variation exists among isolates of the same species?" All of these questions should be considered in the light of the question as to what is the purpose of the study.

The substrates used in our studies were all synthetic and were liquid, semi-liquid and solid. Studies using natural media are now underway. Experiments have been conducted in both the light and the dark and alternating light and dark. Various nitrogen sources have been used but the emphasis has been on media containing one amino acid or combinations of amino acids. Why the emphasis on amino acids? Garrett (1956, p. 34) suggests substrates for soil fungi may be defined as: "living or dead, virgin or partially decomposed plant or animal tissues lying in or on the soil, or soluble products diffusing therefrom."

For most of the year, even in temperate climates with a winter season, fresh substrates for soil-micro-organisms are continuously being provided by animals and plants, as well as the dead cells of other micro-organisms. Animals migrate through and over the soil, sloughing off tissues and excreting while still alive and making a final disposition in favour of their microbial legatees when death at last overtakes them. The roots of plants grow through the soil and while still alive they are continuously excreting small but significant amounts of sugars, amino acids and other organic materials which support an epiphytic root surface microflora and outside of that a rhizosphere microflora (Garrett, 1963). In addition to this work by Garrett; Brink, Snyder, Wilhelm and many others have reported the replacement of old and dying roots with new young vigorous roots in crops such as turf, beans, strawberries, etc. Most of these workers have also reported the secretion of substances from the roots, among them amino acids, that aid in fungus growth on the root or that most important area around the root. Excised tissues and the dead sloughed off portions of the roots become sources of food for fungi and other soil micro-organisms. Using these habitats and sources of food supply the organisms causing disease can now move into the plant (providing other conditions are present for successful penetration and infection) where similar and other sources of nutrients are available. When organisms in the soil die, they too release various kinds and amounts of nutrients, among them amino acids, thus providing sources of nutrients for continued growth. When a length of fungal hypha or a bacterial cell has exhausted its zone of enzymatic erosion, then it cannot obtain any more of the energy-supplying carbon compounds to support life and so it dies. Nitrogen in various forms is then made available to further cellular growth. The paramount role of nitrogen in this process has been emphasized because nitrogen is the mineral nutrient required in largest amount and therefore most likely to be in short supply.

Stanier (1953) has stated: "Microbial environments (and microbial substrates or habitats) are micro-environments (and micro-substrates or habitats) (parentheses are mine), hundreds or even thousands of which be concealed from the gross ecological eye in any gram of soil. A single cellulose fibre provides a specialized environment with its own characteristic microflora yet may occupy a volume of not more than a cubic millimeter."

This abbreviated discussion of substrates or habitats, the importance of micro-environments and the role of released nutrients from dead and dying tissues and organisms indicate, at least to some degree, the reason for our interest in amino acids and sources of nutrition.

In a series of previous initial laboratory experiments conducted by MacLean and Woolliams and from an extensive review of the literature it was found that not all amino acids supported growth of the same organism to the same degree. Not all amino acid supported growth, in fact, some amino acids suppressed growth. In general we found the single amino acid media to fall in three categories:

1. Those amino acids that supported fungus growth.
2. Those amino acids that had no effect on fungus growth.
3. Those amino acids that suppressed fungus growth.

It was with the third group that we became interested. Experiments were designed incorporating groups of the amino acids instead of single amino acids. We were interested to know that if we incorporated two or more amino acids from group 1, would we get a further suppression of fungus growth? We also incorporated amino acids from group 1 with amino acids from group 2 and group 3 and noted the fungus growth. Again we were interested in finding out if one group of amino acids would act as a suppressant on the other groups.

The results are given for the effects of certain amino acids on the growth of *Fusarium nivale* and *Corticium fuciforme*.

Summary

Studies on the ability of the two turf pathogens, *Fusarium nivale* (Fr.) Synder and Hansen and Corticium fuciforme Berk.Wakef. to grow on synthetic basal media using a single amino acid, and combinations of two or more amino acids showed distinct inhibitory or stimulatory effects.

Combinations of two or three amino acids in some cases tended to stimulate growth, suggesting that the inhibitory effects of certain amino acids in combination with other amino acids was reduced.

All the growth regulators at 0.01 g./1. concentration inhibited the growth of *Corticium fuciforme*. *Fusarium nivale* was also inhibited, but to a somewhat lesser extent by most of the growth regulators. 2,4-dichloro-phenoxyacetic acid, naphthalene acetic acid, 2,4,5-trichloro-phenoxypropionic acid, and gibberellic acid stimulated growth of the *Fusarium* organism.

Questions that now arise:

1. Can we adjust growth of fungi to our advantage by incorporating amino acids in the soil or can we adjust growth of organisms on the above-ground parts of the plant by spraying diseased areas?

2. What would be the effect on the plant if it were sprayed with amino acids? Are they in other words phytotoxic?

3. If the released amino acids are in effect supporting fungus growth, is there any way we can get rid of them by breaking them down, by tying them up, or hydrolysing them into other compounds?

4. Are we increasing or adding to our disease problem by adding weed killers or growth stimulators?

Trial 1A

Growth of *Fusarium nivale* on basal medium plus single amino acids and water agar (2 g./1. conc. amino acids). Growth in diameter (cm.) after 5 days.

Treatment No.	Amino acid added		Growth dia.	Density	Pigm.
13	DL—lysine HC1	1	6.00	0.917	2.33
24	no. N—source	2	6.17	0.50	0.00
4	DL—α—amino N-butyric acid	3	6.43	1.50	1.66
15	DL—norleucine	4	6.84	1.50	1.00
7	L—glutamic acid	5	7.10	2.00	3.16
12	L—leucine	6	7.35	1.33	1.00
6	L—cystine	7	7.58	1.00	0.66
19	DL—threonine	8	7.58	1.83	1.66
14	L—methionine	9	8.00	1.33	0.66
11	DL—isoleusine	10	8.08	2.00	1.66
8	L—glycine	11	8.25	2.33	2.00
9	L—histidine HC1	12	8.34	2.165	2.00
2	L—alanine	13	8.43	2.50	3.00
23	L—cysteine HC1	14	8.50	0.917	0.33
18	L—serine	15	8.50	2.33	2.33
16	L—phenylalanine	16	8.50	2.00	2.66
10	L—hydroxy—proline	17	8.58	1.83	2.66
22	DL—valine	18	8.58	2.00	1.66
21	L—tryosine	19	8.84	1.25	1.00
1	Control Sodium nitrate	20	9.00	4.34	4.34
20	L—tryptophane	21	9.17	2.165	1.00
3	L—arginine HC1	22	9.35	2.33	2.66
5	L—aspartic acid	23	9.57	2.50	2.00
17	L—proline	24	10.00	2.66	2.66

Trial 1B

Growth of *Corticium fuciforme* on basal media and water agar and single amino acids (0.2 g./1. concentrations). Growth in cm. diameter after 25 days.

Treatment	Nitrogen source	Order	Growth dia. in cm.
6	L—cystine	1	0.000
7	L—glutamic acid	2	0.000
10	L—hydroxy—proline	3	0.000
13	DL—lysine HC1	4	0.000
14	L—methionine	5	0.000
21	L—tryosine	6	0.000
15	DL—norleucine	7	0.033
16	L—phenylalanine	8	0.050
19	DL—threonine	9	0.050

20	L—tryptophane	10	0.050
4	DL—α—amino-N-butyric acid	11	0.100
8	L—glycine	12	0.100
12	L—leucine	13	0.100
17	L—proline	14	0.100
1	Control 1 Sodium nitrate	15	0.133
22	DL—valine	16	0.133
9	L—histidine HC1	17	0.150
3	L—arginine HC1	18	0.166
5	L—aspartic acid	19	0.166
24	Control II no. N. source	20	0.233
2	L—alanine	21	0.250
18	L—serine	22	0.350
11	DL—isoleucine	23	0.500
23	L—cysteine	24	1.330

Trial 2A

Growth of *Fusarium nivale* on basal media, water agar, and single amino acids (1.07 g./1. concentration). Growth in cm. diameter after 7 days.

Treatment	Amino Acids Added	dia (cm.) growth	Density	Pgm.	Order
14	L—methionine	3.87	1.77	1.66	1
24	no N—source	4.34	0.367	0.00	2
18	L—serine	4.64	1.63	2.00	3
4	DL—α—amino-N-butyric acid	5.17	1.40	1.66	4
9	L—Histidine HC1	6.14	1.06	1.33	5
1	Control I Sodium nitrate	6.17	1.23	1.23	6
15	DL—norleucine	6.17	1.80	2.00	7
8	L—glycine	6.52	1.66	2.66	8
10	L—hydroxy—proline	6.67	1.70	3.00	9
2	L—alanine	7.00	1.86	2.66	10
12	L—leucine	7.34	1.96	2.43	11
11	DL—isoleucine	7.54	1.26	1.66	12
19	DL—threonine	7.67	1.20	1.33	13
22	DL—valine	7.67	1.70	2.33	14
13	DL—lysine HC1	7.84	0.868	1.00	15
16	L—phenylalanine	7.84	2.00	1.33	16
20	L—tryptophane	9.00	1.40	2.66	17
17	L—proline	9.00	1.50	1.77	18
21	L—tyrosine	9.00	1.96	2.33	19

3	L—arginine HC1	did not allow the water agar to solidify
5	L—aspartic acid	
6	L—cystine	
7	L—glutamic acid	

Trial 2B

Growth of *Corticium fuciforme* on basal media, water agar & single amino acids (1.07 g./1. concentration). Growth in cm. diameter after 25 days.

Treatment	Amino acids added	dia. cm. growth	Density	Pigm.	Order
1	Control I Sodium nitrate	0.80	1.10	—	1
24	Control II No. N. source	1.30	1.0	—	2
13	DL—Lysine HC1.	1.36	1.66	—	3
4	DL—α—amino-N-butyric acid	1.40	0.50	—	4
20	L—tryptophane	1.73	1.03	—	5

18	L—serine	1.83	0.96	—	6
19	DL—threonine	1.90	0.63	—	7
16	L—phenylalanine	1.93	0.63	—	8
8	L—glycine	2.06	0.40	—	9
15	DL—norleucine	2.10	1.00	—	10
10	L—hydroxy—proline	2.13	0.76	—	11
14	L—methionine	2.20	1.13	—	12
11	DL—isoleucine	2.40	1.23	—	13
12	L—Leucine	2.43	0.66	—	14
22	DL—valine	2.50	0.63	—	15
21	L—tyrosine	2.50	0.66	—	16
2	L—alanine	2.80	1.10	—	17
17	L—proline	3.06	0.76	—	18
9	L—histidine HC1.	3.23	1.20	—	19
3	L—arginine HC1.	did not solidify as an agar media.			
5	L—aspartic acid				
6	L—cystine				
7	L—glutamic acid				
23	L—cysteine HC1., H_2O				

Trial 3A

Fusarium nivale grown on combinations of 3 amino acids, plus basal media & water agar initial pH of 7. Amino acid source being 0.2 g./1. growth in cm. diameter after 7 days.

Combination No.	Treatment	Order	dia. in cm.	Density	Pigm.
13	DL—norleucine & DL—amino—N —butyric acid & L—hydroxy—proline	1	4.125	1.85	1.25
12	Control I sodium nitrate	2	4.30	0.475	1.875
5	L—leucine plus L—aspartic acid & L—tyrosine	3	4.625	3.75	0.00
1	L—serine & L—cysteine & L methionine	4	4.89	1.70	2.00
6	L—histidine & L—lysine HC1 & L—arginine	5	5.175	2.00	1.00
4	L—methionine & L—serine & L—phenylalanine	6	5.30	2.05	1.00
9	L—alanine & L—arginine & L—cystine	7	6.50	2.05	1.00
8	L—isoleucine & L—glutamic acid & DL—α—amino-N-butyric acid	8	6.74	1.775	1.75
2	L—serine & L—phenylalanine & L—tryptophane	9	7.00	2.20	1.375
11	L—aspartic acid & L—valine & L—cysteine	10	7.50	1.825	1.50
3	L—tryptophane & L—Threonine & L—glycine	11	7.64	2.05	0.750
10	L—tryptophane & L—lysine HC1 & L—proline	12	7.88	1.875	1.00
14	Control II, no nitrogen source, distilled water & water agar	13	8.75	2.125	1.00
7	L—proline, & L—cystine & L—valine	14	9.00	2.125	0.75

Trial 3B

Corticium fuciforme grown on combinations of 3 amino acids, plus basal media, initial pH 7, 0.2 g./1. concentration amino acid source. Gain in dry weight after 25 days.

Combination No.	Treatments	Order	Dry wt. mgm.	pigm. rating	Growth rating	Final pH of media
4	L—tryptophane & L—lysine & L—histidine	1	0.76	0.00	0.1	5.26
5	L—leucine & L—glutamic acid & L—serine	2	0.90	0.00	1.0	5.55
6	L—lysine & L—histidine & L—leucine	3	1.03	3.00	2.00	5.60
7	L—serine & L—tyrosine & L—threonine	4	1.10	0.00	1.00	5.63
14	Control II no nitrogen source	5	2.26	0.00	1.00	5.80
9	L—phenylalanine & DL —α—amino-N-butyric acid & L—valine	6	2.40	2.00	3.00	6.15
13	DL—norleucine & L—cystine DL—amino—N—butyric acid	7	2.70	brown 2.00	1.50	5.65
3	L—methionine & L—glycine & L—isoleucine	8	2.90	0.00	1.00	5.66
8	L—aspartic acid & L—arginine & water	9	3.26	0.00	1.00	5.85
11	L—alanine & distilled H_2O & L—cystine	10	4.10	0.00	1.00	5.85
10	DL—x—amino—N—butyric acid & L—valine & sodium nitrate	11	5.73	black 0.00	2.00	6.016
12	Sodium nitrate Control No. II	12	6.90	0.00	3.00	5.55
2	L—cysteine, & L—methionine & L—isoleucine	13	11.56	4.00	8.00	5.725
1	L—cysteine & L—methionine & L—glycine	14	27.93	5.00	10.00	5.616

Trial 4A

Growth of *Fusarium nivale* on basal media contain single growth regulator (0.01 g./1. concentration). Increase in dry weight after 7 days.

Order	Growth regulator	Treatment number	Dry wt. mycelium mgm.
1	3—(2 furyl) acrylic acid (Kinetin)	11	1.3
2	3—indole propionic acid	9	3.4
3	p—chlorophenoxy acetic acid	2	8.9
4	ethyl—3—indole acetate	13	9.5
5	B—naphthoxy—acetic acid	10	12.0
6	3—indole butyric acid	8	13.8
7	O—chlorophenoxy acetic acid	3	14.9
8	2—4—5 trichlorophenoxy acetic acid	1	17.8
9	3—indole acetic acid	15	21.0
10	α—naphthalene acetamide	12	22.9
11	maleic acid hydrazide	5	29.8
12	Control	16	38.9
13	2,4 dichlorophenoxyacetic acid	7	45.6
14	naphthalene acetic acid	14	84.2
15	2,4,5 trichlorophenoxy propionic acid	6	85.0
16	gibberellic acid (10%) K. salt.	4	101.3

Trial 4B

Growth of *Corticium fuciforme* on basal media containing single growth regulators. (0.01 g./1. conc.)

All of the growth regulators inhibited growth at the 0.01 g./1. concentration.

MINOR ELEMENT NUTRITION OF TURF GRASS

D. J. Wort

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About 40 chemical elements have been shown to occur in plants and of these about 14 are present in appreciable quantities. The kind of plant and the composition of the soil determine the proportion of each of the various elements absorbed.

Fifteen elements are "essential" and must be present in order that the plant may successfully complete its life cycle. Based upon the amounts required by the plant these essential elements are grouped as Major (Macro) and Minor (Micro). The former group includes C, H, O, N, S, P, K, Ca, and Mg. The latter group which is to be considered in this paper, includes Fe, Mn, B, Zn, Cu, and Mo.

All of the mineral elements come from the soil and, with the exception of N, are derived from the parent rock. The N of the air is fixed by bacteria which may be free in the soil or intimately associated with the roots of such plants as clover and alder. The activity of these bacteria is slowed if the pH of the soil falls below 5.5 or if a lack of Mo exists.

It should be emphasized that the total amount of an element in the soil may be of little importance. Availablity is the important feature as far as the plant is concerned. It is possible for the top 6 inches of soil to contain 20 tons of iron (as Fe_2O_3) per acre and the plants growing on the soil may suffer from Fe deficiency. It is evident that any factor which influences availability of the elements is important in turf grass nutrition. The assessment of the nutrient status of a soil requires determination of exchangeable (available) rather than total content of the elements.

Those elements which are present in the soil solution may be readily absorbed by roots and also may be readily leached from the soil. Elements may be adsorbed on the surfaces of the colloidal soil particles such as clay and organic matter. In order to become available in the soil solution these elements must be displaced from the particles by another ion of the same charge, e.g. H^+. This may be illustrated by an equation:

$$\begin{array}{l} \text{Clay}^{-} \\ \;\backslash\;\;^{++} \\ \;\;\text{Ca} \end{array} \; + \; 2H^{+} \; = \; \begin{array}{l} \text{Clay}^{-+} \\ \;\backslash^{+}\backslash\, H \\ \;\;H \end{array} \; + \; Ca^{++}$$

The reaction is reversible. The Ca^{++} released may now be absorbed by the plant or leached away. The soil may become acid because of the large number of H^+ ions adsorbed by the colloidal particles. Methods other than this "Cation Exchange" may also result in the exchange of ions.

The available elements in the soil solution diffuse rapidly and reversibly into the intercellular spaces and cell walls of the root epidermis and cortex and then more slowly and irreversibly (or slowly reversibly) into and through the living cytoplasm of the cells. For this latter part of the path to be traversed energy is necessary.

Since 1840 when the mineral theory of plant nutrition was enunciated by Liebig, much attention has been given methods of determining the mineral needs of plants. Five types of methods are used to determine mineral deficiencies.

1) **Chemical analysis of plants.** The leaves are the most satisfactory parts for analysis. Petioles may be used for quick tissue tests for N, P, Ca, Mg, K, Mn, and Zn. Numerous precautions must be taken in the selection of the leaves. Ordinary methods of analysis are quite slow and the modern trend is to spectrographic and polarographic methods. The

spectrographic method is fast and allows the simultaneous determination of a large number of elements.

2) **Field and pot trials.** The effect of withholding or adding minerals to the soil may be shown by field or pot trials. The method is often very useful and is essentially practical. The cause and remedy are simultaneously indicated. Wrong conclusions may be drawn however. For example, the addition of sulfur to a soil deficient in Mn and Fe may result in a growth stimulus, not because the soil is deficient in sulfur but because the acidifying action of the sulfur frees the bound Mn and Fe.

3) **Soil analysis.** Analysis should indicate the available or exchangeable ions. Chemical and biological methods may be employed. The latter have been used to indicate the status of K, P, Mg, Cu, Zn, Mo, and B. Recently rapid "color tests" have been used. Unfortunately soil analyses are expensive, and require costly equipment. The results need skillful interpretation.

4) **Plant injection and spray.** This method was used originally for the detection of trace element deficiencies in trees. Solutions of mineral salts are injected into leaves or stems or applied as sprays to the foliage. Spraying methods have the great merit of simplicity and are good for all sorts of crops. Usually the results become clearly visible in one or two weeks.

5) **Visual diagnosis.** Deficiencies are recognized by specific symptoms usually associated with the foliage. These are determined in the first instance by growing the plants in nutrient solutions deficient in one or more nutrient elements. Usually the signs are distinct but where they are not, special indicator plants may be grown.

Diagnosis is usually obtained by the use of two different methods. The visual diagnosis is used in combination with one other.

Each of the six minor elements is discussed briefly below.

Iron (Fe)

The deficiency of Fe in soils is seldom a limiting factor. The element is more available in acid soils and it has been suggested that the best way of correcting Fe deficiency is a treatment of the soil to lower its pH. The addition of lime to a soil may decrease the availability of Fe. Although the iron is usually in the ferric form when it is taken into the plant it must be changed to the ferrous state to be active. Manganese is essential for this change. An iron deficiency results in chlorosis of young leaves with the principal veins remaining darker green. Because it is one of the most immobile of the elements it is not moved from the older leaves.

Iron functions within the plant as a part of enzymes of respiration and energy supply and as a part of the chlorophyll-protein complex. It may be supplied as ferrous sulfate or in the chelated form. The sulfate has been found to improve the color of turf grass and to be useful for the control of such diseases as mildew and fusarium. Moss is also controlled by its application to the grass.

Manganese (Mn)

Manganese is required in very low amounts and like iron, it is relatively immobile within the plant. It too is likely to be deficient in alkaline soils and the acidity governs the amount available. A lack of Mn gives chlorosis of the young leaves accompanied by necrotic spots.

The element is involved in the oxidation-reduction of iron particularly and in some way is related to chlorophyll synthesis. Photosynthesis is inhibited in the absence of Mn and recent evidence suggests it is involved in that part of photosynthesis responsible for the evolution of oxygen. The application of manganese sulfate sprays has given a marked improvement in grass color but was without effect on the yield.

Boron (B)

Most species require less than one part per million boron in the nutrient solution. It may be deficient in soils to which lime has been applied since calcium converts the boron to a nonavailable form. Injury due to over-liming may indeed be caused by the consequent unavailability of boron. This element is not readily mobile within the plant and oddly enough there may be an injurious excess in the lower leaves and at the same time the apical meristems may show B deficiency symptoms.

Deficiency symptoms include constriction of the bases of leaves followed by decomposition. While the element may be essential for translocation of sugar in the plant its major function is concerned with the maturation and differentiation of cells. Boron has been added to grass but the results are too variable to show if the effect was favorable or not.

Zinc (Zn)

Zinc is required in very low concentrations and may become highly toxic if the concentration rises. It functions as part of the enzyme suffering from Zn deficience are dwarfed. Other deficiency symptoms protein. Since it is also required for the biosynthesis of tryptophane, from which the plant growth hormone indoleacetic acid is derived, plants suffering from Zn deficience are dwarfed. Other deficiency symptoms incluse abnormally small new leaves mottled with yellow, deformed root tips, and failure of seed formation.

Copper (Cu)

Copper is highly toxic except at low concentrations. Its absence may not result in distinct color characteristics but the leaves may take on a bleached appearance. The element is a constituent of respiratory enzymes and is essential for chlorphyll formation, perhaps through protein synthesis.

Molybdenum (Mo)

This element is required in the smallest amount—one part in 100,000,000 of nutrient solution. It is involved in the reduction of nitrates to ammonia and the further formation of amino acids and proteins. Nitrogen fixing bacteria require Mo and through their action the element has an effect on the nitrogen supply in the soil. Mo deficient tomato plants convert less inorganic phosphorus to the organic form.

Mo deficiency is characterized by yellowing and curling of young leaves and finally all leaves become mottled. The chlorotic areas become puffed and the leaves curl inwards. Application of one oz. per acre has increased crops in various areas.

When nutrition literature is examined little information concerning turf grass is found. The consensus may be summed up in the statement "By and large, deficiency diseases, other than occasional iron troubles, are seldom reported for turf grass".

The reader may find "The diagnosis of mineral deficiencies in plants" by T. Wallace an interesting and informative book. It is published by Her Majesty's Stationery Office, London. Another booklet "Trace element problems in nature" issued by the Botany Department, University of Cape Town, is easy to read and tells a lot in its few pages.

LIGHT RESPONSES OF TURFGRASSES

D. P. Ormrod, University of B.C.

1964 Northwest Turfgrass Conference, September 25, 1964

There are four essentials for the growth of turfgrass. These are heat, moisture, nutrients, and light. The light requirement is principally for the process of photosynthesis by which carbon dioxide from the air and water are converted to sugars in the plant when bright light falls on pigment chlorophyll. There are also several other plant processes which require light. The light used by plants is referred to as white or visible light and has a colour spectrum of wavelengths ranging from about 400 to about 750 millimicrons, with colours ranging from violet to blue to green to yellow to red. Ultraviolet is harmful to plants and infrared is heat energy.

While the human eye perceives light energy with only one pigment, visual purple, absorbing light principally in the green and grading off to violet and red, the plant perceives light by several different pigment systems absorbing light in several different regions of the spectrum. For example, chlorophyll a, the most abundant chlorophyll pigment, has a peak absorption in the blue region and another in the red region. It is interesting to note that green light is most effective on the human eye but hardly absorbed at all by the chlorophyll, being reflected or transmitted, causing the chlorophyll to appear green.

The plant processes affected by light are directly connected with many different growth and development features of plants. Chlorophyll a synthesis is triggered by a light sensitive system which has a primary peak in the orange-red and a secondary peak in the blue. The chlorophyll then becomes active in photosynthesis with resultant dry matter production but in this case the peak photosynthesis activity is in the blue with the secondary peak in the red. Phototropism, the bending of plants toward the light, is triggered by pigments which only absorb light in the violet to blue regions. The recently discovered pigment phytochrome has been found to have two forms. One absorbs in the red region and causes the induction of leaf enlargement, rhizome formation, flower initiation and development, and many other growth and development features. The other form absorbs in the far-red or infrared region and causes reversal of the same processes induced by the pigment form absorbing in the red. Some processes like photosynthesis require high light intensity while others can operate at lower energy or intensity levels.

The normal source of light is from the sun. Open sunlight has a more or less uniform spectral colour distribution from the blue through to the infrared. Light energy is thus provided for photosynthesis, phototropism and other light processes and there is an approximately equal balance of red and far-red phytochrome effects. On the other hand, if artificial light is used for plant propagation, the spectral colour distribution is not uniform. Fluorescent lights have a peak in the yellow-orange region and have much lower energy in the blue and red. Tungsten or incandescent lights have low energy in the blue and a uniform increase of energy on into the infrared. Tungsten lights have a much higher heat energy production than fluorescent. For a reasonably uniform light simulating sunlight, fluorescent lights are usually combined with tungsten lights. If sunlight passes through leaves the spectral colour distribution is drastically changed. The blue and red portions are absorbed and the transmitted light is relatively higher in the green. It is relatively less effective in photosynthesis in subsequent leaves struck by the light and is relatively higher in far-red phytochrome activity.

Light measurement may be by either one of two different ways. Weather stations use the Eppley pyrheliometer which converts light energy to heat energy and absorbs uniformly from violet through to infrared. On the other hand, light meters with selenium cells absorb light with a maximum in the green extending into the blue and red and can be made to estimate visual purple or human sight effectiveness with a "viscor" or visual corrected filter. The Eppley is thus more desirable for measurement of light energy for plant processes while the selenium cells are more useful for lighting for humans.

Probably the most serious problem in turfgrass related to light is that of the shaded lawn. The area under trees may appear to be light and airy but the light intensity and colour distribution will be unsatisfactory for grass growth. If the trees have an open leaf arrangement there may be sufficient sunlight coming through to support healthy grass. A figure of two hours sunlight per day has been suggested as the minimum for grass growth. There are also marked seasonal variations in potential hours of sunlight and in the density of tree leaves which should be considered.

Plant growth form may be quite different in shade or partial shade because of the different balance of colour in the light. Mowing patterns should possibly differ in shade because of this. Trees can be trimmed or removed if excess shade is a problem. The most shade tolerant species should be used and other ground cover species may be used in extreme cases.

Light also has an effect on the wilting of grass. It indirectly causes more shooting or tillering of the grass plants. Some species are particularly responsive to light in that tillering is directly related to light intensity. Also mowing practice should be such that sufficient leaf surface remains for adequate photosynthesis to provide sugar energy for plant metabolism and growth. Again, there are great differences among species in the minimum amount of leaf which must be left for adequate growth.

Light also has an affect on the wilting of grass. It indirectly causes the leaf stomata to open with resultant greatly increased evaporation of leaf water and subsequent wilting unless there is adequate soil moisture and rapid translocation of water to the leaves. Experiments have shown conclusively that wilting is much more rapid in bright artificial light or sunlight. Activities like placing stolons or transplanting sod should therefore be done at night, if possible. Also mowing might be generally more satisfactory if done at night, except that the piling of dewy clippings should be avoided.

Another effect or light is related to the length of the day or photoperiod. The principal process affected by photoperiod is that of seed-head formation, for which only low light intensities are required. Grass species normally head in late spring or early summer but under a normal mowing regime good lawn species do not have a chance to head. The seasonal variations which may occur in grasses are probably related in part to photoperiod, however, and with the advent of night golf it will be interesting to see if plant form differs near the lighting fixtures where there will be an artificially long photoperiod.

Light also has other known effects. For example, insect activity in lawns may be a function of light intensity and photoperiod. Further turf research may show even more light responses of turfgrasses.

EFFECT OF HERBICIDES ON SPEEDWELL (Veronica persica) ON TURF

E. C. Hughes

B.C. Department of Agriculture

During July 24-27 a series of duplicate 100 sq. ft. herbicide treatments were applied on severe infestation of speedwell on a primarily bluegrass (Poa sp.) turf. Weather was warm and sunny, followed by rains. Soil type was sandy loam. All treatments excepting Zytron & dicamba granular, were applied with a knapsack in 100 g.p.a. water using a pressure of 30 p.s.i. Treatments and results obtained from an average rating on September 8 were as follows—

Chemical	Rate/A	% Control	Chemical	Rate/A	% Control
Tordon	1 lb/A	75 %	C 3470	5 lb	99 %
"	2 "	99 %	Kilmore	2 lb	12.5%
"	3 "	99 %	"	3 lb	52 %

Silvex	1 "	5 %	Killex	2 lb	40 %
"	2 "	7.5%	"	3 lb	62.5%
Zytron E.C.	7.5 "	90 %	Tordon 101	2 lb	25 %
"	10 "	**99 %**	Tordon 101	3 lb	80 %
"	15 "	99 %	Celatox	¾ lb	85 %
Zytron (granular)	7.5 "	30 %	"	1½ lb	88.5%
"	10.0 "	45 %	Diphenamid	4 lb	35 %
"	15 "	72.5%	"	6 lb	62.5%
CMPP ester	3 "	72.5%	Dicamba E.C.	2 lb	25 %
"	4 "	81 %	" "	4 lb	87.5%
Supertox	2 "	10 %	Dicamba gran	2 lb	5 %
*MBC 102	2 "	25 %	" "	4 lb	50 %
" "	3 "	52.5%	Betasan	15 lb	0
Endothal	1.9 "	94 %	"	30 lb	0
"	2.8 "	96.5%	"		

*Mixed phenoxypropionic & phenoxyacetic acids

At the higher rates Tordon, Zytron granular, endothal, kilmore, diphenamid, dicamba and C 3470 caused grass injury ranging from 15-40%. Slight grass injury occurred from lower rates of Tordon, CMPP, Killex, Tordon 101 and Celatox. Diphenamid and Zytron did not affect daisy or buttercup. Chickweed recovery was rapid in the endothal plots. MBC 102 was effective on lawn daisy at the higher rate.

(Contributed by the B. C. Department of Agriculture, New Westminster, B.C.)

To be entered in Research Report by Mr. R. M. Adamson, Experimental Farm, Saanichton, B.C. Copy sent to E. S. Molberg, Saskatchewan.

EFFECT OF HERBICIDES ON LAWN DAISY (Bellis Perennis) IN ESTABLISHED TURF

Sprayed July 10, 1963

E. C. Hughes

100 sq. ft. plots treated on the above date were assessed August 15, 1963 and reported upon in the 1963 Research report, Western section, N.W.C. On May 5, 1964, those plots were reassessed. Treatments of 2-CMPP (alone and in combination), Zytron and Silvex had generally lost their effectiveness. Dicamba was partially effective at the 2 lb/A rate. Tordon was outstanding in effectiveness. Ratings of note were as follows. Grass growth was normal.

Chemical	Rate/A	Daisy % Control	Chemical	Rate/A	Daisy % Control
*Tordon	8 oz/A	60%	Dicamba	1 lb	10%
"	16 oz	95%	"	1½ lb	20%
"	1.5 lb	20%	"	2 lb	50%
"	2 lb	50%			

(Contributed by the B. C. Department of Agriculture, New Westminster, B. C.)

To be entered in Research Report by Mr. R. M. Adamson, Experimental Farm, Saanichton, B.C.

EFFECT OF HERBICIDES ON SPEEDWELL (Veronica persica) IN TURF. Sprayed July 3, 1963

E. C. Hughes

100 sq. ft. plots treated on the above date were assessed August 15, 1963, and reported upon in the 1963 Research report, Western section, N.W.C. On May 5, 1964, these plots were reassessed. Complete or nearly complete recovery of speedwell occurred. Plots of sprays containing

2-CMPP (alone or in combination), Dicamba, Silvex, Endothal or Tordon. Zytron (DMPA) applied as a spray was outstanding in its residual control as indicated below.

Chemical	Rate/A	% Control Speedwell
DMPA	10 lb	75%
"	15 lb	95%

Recovery of grass in these plots indicated a tendency to coarser species but this may be due to very dense speedwell growth initially crowding out the finer species however.

(Contributed by the B. C. Department of Agriculture, New Westminster, B. C.)

To be entered in Research Report by Mr. R. M. Adamson, Experimental Farm, Saanichton, B.C. Copy sent to E. S. Molberg, Saskatchewan.

EFFECT OF HERBICIDES ON ESTABLISHED TURF. QUEEN'S PARK

E. C. Hughes

On July 23, 1964, during sunny warm weather, 100 sq. ft. duplicate plots of established turf, primarily bluegrass (poa sp.) with some mixed bentgrass (Agrostis sp), was sprayed at 80 g.p.a. water using various herbicides, soil type was sandy loam. Weeds present were primarily narrow and broad leaved plantain (Plantago sp.) black medic (Medicago lupulina), false dandelion (Hypochoeris radicata) a white clover (Trofolium repens) with some daisy (Bellis perennis). A fertilizer mix 20—10—5 at 120 lbs. and 240 lbs./A, supplying 1 lb. and 2 lb. 2,4-D amine/A was also compared. Results were as follows as rated September 6th.

Chemical	Rate/A	% Weed Control	% Grass Injury	Chemical	Rate/A	% Weed Control	% Grass Injury
Betasan	15 lb	0	0	2,4-D ester	16 oz	80	0
"	30 lb	0	0	"	32 oz	93.5	5
Tordon	2 oz	90	0	2,4-DB ester	24 oz	60	0
"	4 oz	97.5	0	Tordon 101	16 oz	99.5	5
"	8 oz	99.5	0	MCPA	16 oz	72.5	0
"	12 oz	100	5	"	32 oz	82.5	0
"	16 oz	100	5	*RD 7693	4 oz	12.5	0
Dicamba	16 oz	85		"	8 oz	30	0
"	32 oz	94.5	5	Dacamine 4D	8 oz	50	0
*H 430	16 oz	97.5	7.5	"	16 oz	65	0
"	32 oz	98.5	10.0				
Silvex	16 oz	70					
"	32 oz	95					
Killex	16 oz	96.5					
"	32 oz	97.5	5				
*NPH 112	16 oz	80					
"	32 oz	99					
Supertox	16 oz	93.5					
"	32 oz	98	5				
*MBC 102	16 oz	95.5					
"	32 oz	99.5	5				
2-MCPP	16 oz	95					
Weed-feed Fert.	120 lb	45					
"	240 lb	37.5					

*H 430—Combination of 2,4-D, 2-MCPP & dicamba

*NPH 112—mixture of 2-MCPP & 2,4-D

*RD 7693—coded

*MBC 102—mixed phenoxypropionic & phenoxyacetic acids

In general Tordon was excellent on all weeds, dicamba was ineffective on plantain, 2-MCPP ester and compounds containing 2 MCPP at lower rates were somewhat ineffective on false dandelion and daisy. 2,4-D ester at 16 oz/A gave poor control of clover. The fertilizer 2,4-D mix was effective mainly on plantain but was markedly inferior to foliar

sprays. Tordon was the most effective treatment on daisy followed by dicamba and 2-MCPP combinations.
(Contributed by the B. C. Department of Agriculture, New Westminster, B. C.)
To be entered in Research Report by Mr. R. M. Adamson, Experimental Farm, Saanichton. Copy sent to Mr. E. S. Molberg, Saskatchewan.

THE 1964 TURFGRASS CONFERENCE ROUNDUP "THE ECOLOGY OF TURFGRASS"

By Donald A. Hogan

One definition of ecology could be stated as the study of biology concerning the relationship of living organisms and their environment in plant and animal life. We have heard of the slang phrases, "You can't beat city hall," or, "If you can't beat them, join them," or, as Dr. Daubenmire so aptly stated, "You can't win a fight with nature." Most speakers have pointed to environment and conditions favorable for the growth of turfgrass or, conversely, unfavorable for undesirable plants, diseases, and so forth when exercising control.

In many instances, the speakers infer that turfgrass maintained for purposes of sports utilization or with the requirement of supporting traffic is an artificial culture, as Dr. Neil MacLean expressed this morning. Recommendations included the soil that serves as a media for turfgrass life be prepared on the basis of a laboratory formula of compounded materials.

Increased use of areas, for example roadways, require current adequate treatment to support the demands placed upon them. Certainly in turf maintenance there is a need which commands consideration of the fundamentals of natural environment and timing to achieve the best results within a reasonable budget when applying management practices. Possibly, this is exactly what Dr. Goss meant when he posed the question, "Are we growing as good a turf as we know how to?" A simple observation as mentioned by Mr. Dick Turley that adequate fertilization program was the most successful control for red thread at their experiment station. Certainly, we have heard of this basic theory before.

When exchanging ideas, considering the results of research work, or applying recommendations, many times turf managers take action without adapting this to their specific situation or conditions. Frequently failure results and the manager criticizes the research program immediately, without analyzing his circumstance and adjusting accordingly like a responsible professional person should. This leads to a point frequently used by the managers, "Research and recommendations may be alright for another area, but my conditions are different." To this our travels to many varied parts of the United States and Canada point out that the following is true: While conditions differ between the various geographical locations requiring locally adapted turfgrass maintenance practices, the basic fundamentals of good management do not differ.

There seems to be occasions of differences of opinion between educators and research people as to which approach should be pursued. The ecologic consideration might suggest that balance is the most significant factor. Certainly, the correct environment along with natural habitat conditions must be attempted within the limits of the specific restrictions that affect the turf manager. Discriminate chemical utilization dictated by circumstances of unnatural environment or excessive use of an area along with time limitations on the results, also, is an important part of good turfgrass maintenance.

Therefore, it is generally agreed that research, knowledge, experience, and intelligence must be combined to result in a successful turf maintenance program and the ecological factors must never be violated or disregarded.

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Early Bird Spray and Garden Service	1523 63rd St.	Everett, Wash. 98202
Elks Golf & Country Club	Box 187	Selah, Wash.
Enumclaw Golf & Country Club	Box 599	Enumclaw, Wash.
Eugene Country Club	255 Country Club Rd.	Eugene, Oregon
Everett Legion Memorial Golf Course		Everett, Wash.
Everett G & C Club	Box 146	Everett, Wash.
Evergreen Memorial Park	11111 Aurora Ave. N.	Seattle, Wash. 98133
Fircrest Golf Club	6520 Regents Blvd.	Tacoma, Wash.
J. E. Fisher	Box 654A	Issaquah, Wash.
Faulkner Spray Service	2820 S. 150th	Seattle, Wash. 98188
Forest Lawn Cemetery	5409 Kitsap Way Box 1279B	Bremerton, Wash.

Forest Lawn Inc,	6701 30th AVES. W.	Seattle, Wash. 98106
Ft. Lewis Golf Course	Rt. 3	Ft. Lewis, Wash.
Floral Hills, Inc.	409 Filbert Rd.	Alderwood Manor, Wash.
H. D. Fowler, Inc.	13440 S.E. 30th St. Ave. S.W.	Bellevue, Wash. 98004
General Spray Service of Magnolia	1031 N.E. 114th	Seattle, Wash.
Glendale Country Club	Box 797	Bellvue, Wash.
Glendoveer Golf Course	14015 N.E. Glisan St.	Portland, Oregon
Grays Harbor Country Club	Rt. 1	Aberdeen, Wash.
Greenup Spray Service	12437 1st. Ave. S.W.	Seattle, Wash.
Greenwood Memorial Terrace Co.		
John S. Haines	4700 E. Oregon Rt. 4	Bellingham, Wash.
Hemphill Bros. Inc.	201 Boren Ave. N.	Seattle, Wash. 98109
Hercules Powder Co.		San Francisco, Calif.
Hillcrest Country Club	Box 1083	Boise, Idaho
Don Hogan	9060 37th Ave. S.	Seattle, Wash. 98108
John Holms	Box 1196	Fairbanks, Alaska
Inglewood Country Club	Rt. 6	Kenmore, Wash.
Jacklin Seed Co.	8803 E. Spague	Dishman, Wash.
Jackson Park Golf Course	1000 N.E. 135th St.	Seattle, Wash. 98125
Jefferson Golf Course	4101 Beacon Ave. S.	Seattle, Wash. 98144
Johns-Manville		
Kelso Elks Golf Club	Box 247	Kelso, Wash.
Kitsap Golf & Country Club	Box 3971	Bremerton, Wash.
Lasco Industries	1561 Chapin Road 17716-21st. S. N.E.	Montebello, Calif. Seattle, Wash. 98155
Lewiston Golf & Country Club		Lewiston, Idaho
Liberty Lake Golf Club	Box 235	Liberty Lake, Wash.
Lilly Co.	1900 Alaska Way	Seattle, Wash. 98101
Longview G & C Club	Box 1075	Longview, Wash.
McChord Air Force Golf Course		McChord, Wash.
Manito G & C Club	Box 8025 Manito Station	Spokane, Wash.
Mitchell Lumber Co.	Box 555 338-An. State St.	Lake Oswego, Oregon
Miller Products Co.	7737 N.E. Killingsworth	Portland, Oregon
Mountain View Memorial Park	4100 Steilacoom Blvd. S.W.	Tacoma, Wash. 98409
Mount Vew Cemetery	Box 632	Walla Walla, Wash.
Mt. Si Golf Course	Box 68	North Bend, Wash.
Moses Lake Golf Course T. K. Nanto	P.O. Box 1694	Moses Lake, Wash.

Northwest Mower	7710 24th N.W.	Seattle, Wash. 98107
Olympia Country & Golf Club	Box 1063	Olympia, Wash.
Overlake Golf Club	Box 97	Medina, Wash.
Oswego Lake Country Club	20 Iron Mt. Blvd.	Oswego, Oregon
Pacific Equipment Co.	1001 S. Jackson St.	Seattle, Wash. 98104
Peace Portal Golf Club	190 King George Hwy.	White Rock, B.C. Canada
Portland Golf Club	5900 Scholls Ferry Road	Portland, Oregon 97219
Prineville Golf Club	133 E. 3rd St.	Prineville, Ore.
Pullman Golf Club	1235 College Station	Pullman, Wash.
Rainier G & C Club	1856 S. 112th St.	Seattle, Wash. 98188
Ramsey Waite Co.	Box 5173	Eugene Oregon
Rogue Valley G & C Club	Box 427	Medford, Oregon
Roseburg Golf Club	Rt. 2	Roseburg, Oregon
Royal Oaks Country Club	8917 N.E. 4th Plain Rd.	Vancouver, Wash.
Salishan Beach Golf Club		Gleneden, Oregon
Sand Point Country Club	8333 55th Ave. N.E.	Seattle, Wash. 98105
O. M. Scott & Sons	Box 327	Salem, Oregon
Seattle Golf Club	145th N. and N. Greenwood	Seattle, Wash. 98177
Seattle Park Dept.	100 Dexter Ave. N.	Seattle, Wash. 98109
Shelton - Bayshore Golf Club	P.O. Box 89	Shelton, Wash.
Shoreline School District No. 412	N. E. 158th and 20th N.E.	Seattle, Wash. 98125
Ed Short Co.	6th Ave. S.	Seattle, Wash. 98104
Spokane Country Club	Rt. 5	Spokane, Wash.
Spokane Park Dept. (City of Spokane)	504 City Hall	Spokane, Wash.
Sumner Cemetery	Box 55	Sumner, Wash.
Sunset Hills Memorial Park	Box 561,	Bellevue, Wash.
Loyd Stitt	321 W. Prairie	Wheaton, Ill.
Tacoma Country & Golf Club	Gravelly Lake Drive S.W.	Tacoma, Wash. 98499
Tacoma Seed So.	Box 468	Tacoma, Wash.
Taylor, Pearson & Carson, Ltd.	1100 Venables St.	Vancouver, B. C. Canada
Three Lakes Public Colf Course	Box 234	Wenatchee, Wash.
Tri-City Golf Club	Box 456	Kenewick, Wash.
Turfco Industries Inc.	1340 N. Northlake Way	Seattle, Wash. 98103
City of Twin Falls	Box 867	Twin Falls, Idaho
Van Waters & Rogers, Inc.	4000 1st Ave. S.	Seattle, Wash. 98104
Veterans Memorial Golf Club		Walla Walla, Wash.
Croydon Wagner	Box 3417	Tacoma, Wash. 98499
Wandemere Golf Club	Rt. 5	Spokane, Wash.

C. R. Walters Co.		Bothell, Wash.
City of Walla Walla		Walla Walla, Wash.
Walla Walla Country Club	Box 523	Walla Walla, Wash.
Turf and Toro Supply Co.	1200 Stewart Ave.	Seattle, Wash. 98101
West Seattle Golf Course	4470-35th Ave. S.W.	Seattle, Wash 98106
Waverley Country Club	1100 S.E. Waverley Dr.	Portland, Oregon 97222
Wellington Hills Golf Club		Woodinville, Wash.
Wenatchee Golf & Country Club	Box 1479,	Wenatchee, Wash.
Western Golf Course Supply	1240 S.E. 12th Ave.	Portland, Oregon
Western Plastics Corp.	3110 Ruston Way	Tacoma, Wash. 98402
Norman H. Woods	Box 204, Station A	Vancouver, B. C. Canada
Morton Chemical Co.	1620 S.W. Custer St.	Portland, Oregon
Velsicol Co.	76 Anza Ct.	Fairfield, California
New Meadow Lark Country Club		Great Falls, Montana
Western Farmers Association	201 Eliot W.	Seattle, Wash. 98119
Yakima, Metropolitan District of	P.O. Box 171	Yakima, Wash.
Vancouver Golf Club		Vancouver, B. C. Canada

ATTENDANCE AT 1964 NORTHWEST TURFGRASS CONFERENCE

Milt Allen	Enumclaw, Wash.
R. Ashworth	Vancouver, B. C.
R. Bailey	Burnaby, B. C.
Harvey Banks	Bremerton, Wash.
Clayton Baunan,	Kirkland, Wash.
Milt Bauman	Kirkland, Wash.
Norris Beardsley	Spokane, Wash.
Heinz Berger	W. Vancouver, B. C.
Allen Blair	Seattle, Wash.
Andy Brice	Vancouver, B. C.
Roscoe Brown	Vancouver, B. C.
Russell Brown,	Richland, Wash.
Jim Bugai	Seattle, Wash.
Jack Bytelaar	Vancouver, B. C.
Dr. V. Brink	Vancouver, B. C.
L. Butterworth	Victoria, B. C.
John Carper,	Seattle, Wash.
Jack Chase	Seattle, Wash.
Art Clancy	Vancouver, B. C.
Dave Clark	Vancouver, B. C.
Virgil Clark	Everett, Wash.
C. Clement	Vancouver B. C.
Bob Cockburn	Everett, Wash.
Ron Cole	Fairfield, Calif.
W. Crane	Richmond, B. C.
Jack Cronin	West Vancouver, B. C.
Len Collett	Vancouver, B. C.
Jim Crook	Vancouver, B. C.
Reg. J. Crowe	Vancouver, B. C.
Norm DeChambeau	Bothell, Wash.
Graham Drew	Vancouver, B. C.
R. H. Dennis	West Vancouver, B. C.
Don Dye	N. Portland, Oregon
Jim Dickie	N. Vancouver, B. C.
Jack Daniels	Seattle, Wash.
Harold Drobott	Richmond, B. C.
A. F. Ellis	Victoria, B. C.
J. D. Evans	Vancouver, B. C.
Cliff Everhart	Spokane, Wash.

N. H. Fallis	Vancouver, B. C.
Bernie Fischer	Boise, Idaho
Max Fletchall	Salem, Oregon
Paul Florence	Salem, Oregon
Ed Fluter	Portland, Oregon
Bud Fraser	Whalley, B. C.
Russ Fouts	Albany Oregon
Les Foster	Richmond, B. C.
Bill Gabel	Walla Walla, Wash.
Frank Gavan	Victoria, B. C.
Ron Getchell	Salem, Oregon
Dick Gettle	Bellingham, Wash.
L. Gleason	Vancouver, B. C.
Manny Gueho	Vancouver, B. C.
John Halse	Vancouver, B. C.
J. E. Hancock	New Westminster, B. C.
John Harrison	Hayden Lake, Idaho
George Harvey	Astoria, Oregon
Dick Haskell	Seattle Wash.
Henry, Hofseth	Richmond, B. C.
Don Hogan	Seattle, Wash.
Neale Honeybourne	Kamloops, B. C.
Jim Hughes	Fresno, Calif.
Dave Hulo	Seattle, Wash.
Thompson Hayward	Vancouver, B. C.
John Haines	Bellingham, Wash.
Carl Hansen	San Francisco, Calif.
Ron Johnstone	Vancouver, B. C.
Tom Keel	Roseburg, Oregon
Heinz Knodler	Richmond, B. C.
Carl Kuhn	Bellevue, Wash.
Henry Land Jr.	Seattle, Wash.
Dean Latimer	Tacoma, Wash.
George Lawton	Olympia, Wash.
Howard Lufkin	Seattle, Wash.
C. J. Mackay	Vancouver, B. C.
Sam McCallum	Langley, B. C.
Gordon McKay	Vancouver, B. C.
Don McLeod	Richmond, B. C.
Roy Maling	
Art Marston	Seattle, Wash.

E. McCready	Vancouver, B. C.
Ken McKenzie	Seattle, Wash.
A. L. McLeod	Vancouver, B. C.
R. W. Malpass	Eugene, Oregon
Nicholas Metal	Vancouver, B. C.
A. Miller	Vancouver, B. C.
A. Mitchell	N. Surrey, B. C.
Don Miller	Seattle, Wash.
R. Murphy	Sardis, B. C.
Ken Morrison	Pullman, Wash.
Doug Oliphant	Portland, Oregon
Richard Oliphant	Portland, Oregon
W. Peltzer	Vancouver, B. C.
Robert Pierson	Vancouver, B. C.
Jim Porterfield	Salem, Oregon
Glen Proctor	Seattle, Wash.
Larry Proctor	Tacoma, Wash.
Ken Putnam	Seattle, Wash.
Byron Reed	Portland, Oregon
Clarence Ripley	Spokane, Wash.
Jim Rivers	Nanaimo, B. C.
Chen Rowe	Tacoma, Wash.
Robbie Robinson	Toronto, Canada
E. T. Rodway	Vancouver, B. C.
Louie Schmidt	Spokane, Wash.
Lloyd Scott	Seattle, Wash.
R. Schwabauer	Eugene, Oregon
Hans Seidlitz	Richmond, B. C.
Jack Schultz	
J. Sinker	Vancouver, B .C.
H. Smith	W. Vancouver, B. C.
John Snook	W. Vancouver, B. C.
Bob Staib	San Francisco, Calif.
Tim Steenberger	Burnaby, B. C.
Loyd Stitt	Wheaton, Ill.
Paul Stockstad	Burnaby, B. C .
Mike St. Jacque	Seattle, Wash.
Merrill Street	Seattle, Wash.
David Tait	Vancouver. B. C.
Tommy Thorpe	Victoria, B. C.
Norman Theberge	Haney, B. C.
Myron Tucker	Boise, Idaho

F. Verkerk	Kelowna, B. C.
A. van der Pauw	Haney, B. C.
Mr. Weddle	Spokane, Wash.
John Wainscott	Saanichton, B. C.
Joe Ward	Christmas Valley, Oregon
K. M. Warner	Vancouver, B. C.
A. L. Warner	Vancouver, B. C.
Bernard Wellenbrink	Vancouver, B. C.
Sidney White	The Dalles, Oregon
W. Wisby	Vancouver, B. C.
Norman H. Woods	Vancouver, B. C.
John Zoller	Eugene, Oregon