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Look For Turf Pests Now

R. N. Jefferson, F. S. Morishita,[1] A. S. Deal,[2] and W. A. Humphrey[3]

The purpose of this article is to briefly discuss the habits and control of certain pests. For a more complete account of turfgrass and dichondra pests the reader is referred to the following articles which have been published in California Turfgrass Culture: Turfgrass and Dichondra Pests in Southern California (Vol. 9, No. 2, April, 1959), Progress Report on the Bermudagrass Mite and the Frit Fly (Vol. 12, No. 2, April, 1962), and Dichondra Pests in Southern California (Vol. 14, No. 3, July, 1964). A summary of control measures is given in Insect Control on Lawns (OSA #154) which may be obtained from your Farm Advisor.

Dichondra. – If you have a dichondra lawn be on the lookout for the flea beetle Chaetocnema magnipunctata Gentner. The adult beetles (Fig. 1) are black and very small, about 1/25 of an inch long. They skeletonize the leaves which then turn brown. The injury is very characteristic (Fig. 2) and can easily be recognized with an ordinary magnifying or reading glass. Damage is localized or spotty at first, and since the beetles are so small it is often assumed that the damage is due to lack of water or fertilizer burn.

FIG. 1. ADULT FLEA BEETLES, CHAETOCNEMA MAGNIPUNCTATA GENTNER.

FIG. 2. TWO DICHONDRA LEAVES (ENLARGED) SHOWING CHARACTERISTIC FLEA BEETLE DAMAGE.

Damage from flea beetles is most likely to occur during the warm months – from May through October. For control, spray the lawn with DDT or one of the preparations containing DDT and designed for cutworms. Apply at the rate given on the label for cutworms, and use enough spray to thoroughly wet the foliage and the surface of the ground.

Snails and slugs are perennial pests of dichondra. In "Dichondra Pests in Southern California" we recommended Zectran sprays for control. Since Zectran may go off the market we may be left with metaldehyde sprays or baits containing metaldehyde or metaldehyde and calcium arsenate. Our experience of the last few years indicates that baits are probably the most satisfactory method of control for most home owners. In 1965 a new bait appeared on the market – Germain's Snail, Slug & Insect Killer. This bait is in the form of granules impregnated with metaldehyde and carbaryl (Sevin). We tested this bait and found it to be effective. One advantage of this bait is that the granules are so small that when applied it offers no hazard to children and pets. And there is no danger of damage to plants which sometimes occurs with baits containing calcium arsenate.

Now is the time to work on slug and snail control, and persistence is the key to success in controlling these pests.

1 Dept. of Entomology, University of California, Riverside.
2 Extension Entomologist, University of California Agricultural Extension Service, Riverside.
3 Farm Advisor, University of California Agricultural Extension Service, Orange County.

Billbugs. The larvae or grubs of several species of billbugs (Coleoptera : Curculionidae) feed on the roots of grasses, and though sort of a sporadic pest, may cause serious damage. The grubs (Fig. 3) are white and legless, and from 1/4 to 3/8 of an inch long. Damage is similar to that from white grubs – the grass is killed and the turf can be rolled up like a rug.

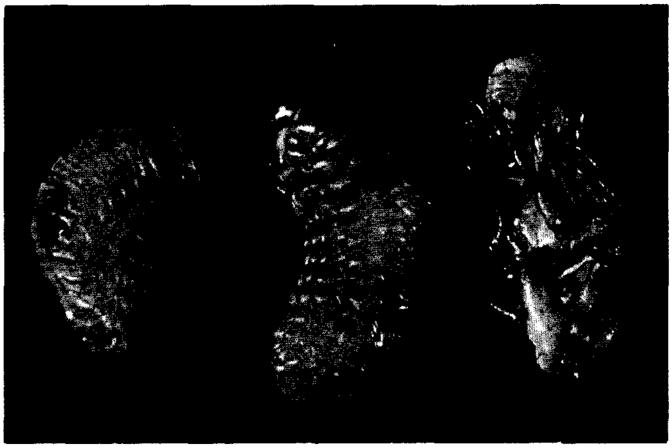

FIG. 3. TWO BILLBUG LARVAE AND A PUPA.

We are including this note on billbugs because in the last few years several new golf courses have suffered serious damage to fairways from billbugs. Chlordane at 20 pounds of active ingredient per acre is the standard recommendation. However, Heptachlor at 4 to 5 pounds of active ingredient per acre has proved effective. It should be remembered that control may be slow since the insecticide must be washed down to the root zone to be effective.

Bermudagrass mite . -The bermudagrass mite, *Aceria neocynodonis* Keifer, is microscopic in size. It is found in the terminal leaf sheaths and its feeding causes stunting and a "witches broom" effect (Fig. 4). Experiments conducted by F. S. Morishita in 1961 indicated that diazinon (5 pounds of the active ingredient per acre) was the most satisfactory material for control. The experiments also indicated that proper cultural practices – thatch removal, aeration and fertilization-were also important and while not necessarily eliminating the need for insecticide treatments would reduce the number of treatments needed. These conclusions have been borne out in actual practice and have been confirmed by research in Arizona. Butler and Scanlon (1965) in summarizing the results of several years research stated "Insecticidal treatments in the early spring do not give appreciable reduction of bermudagrass mite damage or significant improvement in the green color of the grass. A combination of both insecticide and fertilizer is required to give both a significant reduction in injury caused by the mites as well as an increase in the green appearance of the grass. "

If your bermudagrass does not respond this spring, check for the bermudagrass mite.

FIG. 4. INJURY TO BERMUDAGRASS BY THE BERMUDAGRASS MITE, ACERIA NEOCYNODONIS KEIFER. NOTE SHORT INTERNODES AND "WITCHES BROOM " EFFECT.

Frit fly.-Damage from the frit fly, *Oscinella* frit (Linn.), usually occurs from April through September, but in certain areas has occurred as early as February or March. The frit fly is a very small, black fly. The larvae or maggots feed on the grass blades and tunnel in the stems. While the fly breeds in the fairways, as far as we know, significant damage has occurred only in the greens. The symptoms of damage appear first on the collars, usually first on the high or upper sections, and then move in toward the center of the green. Diazinon at 5 pounds of the active ingredient per acre has given good control. This treatment also controls lawn moths.

Figures 5 and 6 show the 1964 results of weekly samplings of the frit fly population at the Los Coyotes Country Club in Orange County. The height of the bars indicates the number of flies caught with 50 sweeps of a net. The sampling was done just before noon and the temperature shown was the temperature at that time-not the maximum for the day.Figure 5 represents the catches from a putting green and figure 6 the catches from the fairway about 100 yards upwind from the green. The small circles below the bars indicate the dates the green was sprayed for frit fly control. The fairway was not sprayed.

Figures 5 and 6 show that in 1964 the fly population built up in March and reached a peak in June. Adult flies were taken every month of the year, and this was also true in 1962 and 1963. In 1962 there was a peak about the end of April, and another at the end of June with the fly population remaining high until the end of August. In 1963 the maximum catch was in the latter part of April with another peak in June. The fact that flies were taken every month of the year indicates that in southern California breeding continues through the winter months. According to Essig (1958) in the midwest there are 4 generations a year with the insect overwintering in the larval stage. He gives the life cycle – from adult to adult – as varying from 21 to 58 days. We suspect that in southern California during the warmer months the life cycle is slightly less than a month. Experience indicates that once populations have built up in the spring that treatments will have to be applied at approximately monthly intervals to prevent damage.

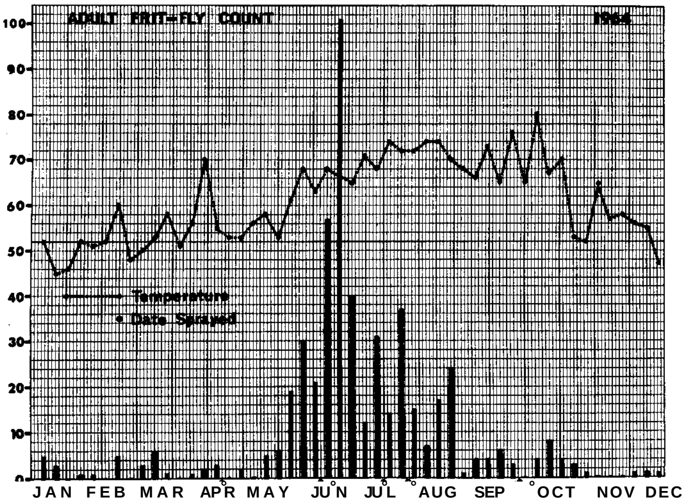

FIG. 5 RECORD OF WEEKLY SAMPLING OF FRIT FLY POPULATION ON PUTTING GREEN AT LOS COYOTES COUNTRY CLUB, ORANGE COUNTY.

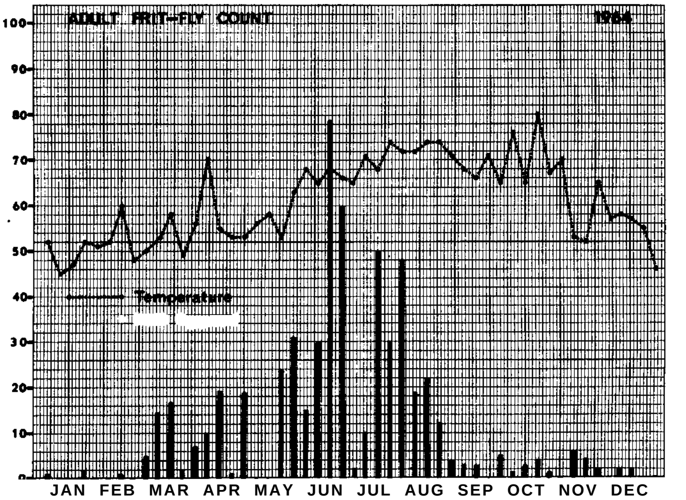

FIG. 6 RECORD OF WEEKLY SAMPLING OF FRIT FLY POPULATION OF FAIRWAY AT LOS COYOTES COUNTRY CLUB, ORANGE COUNTY.

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Butler, G. D., Jr., and T. Scanlon. 1965. Evaluation of materials for the control of the bermudagrass mite. 1965 Report on Turfgrass Research. Report 230, pp. 11-16 University of Arizona.

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Why Nitrogen Fertilization Controls The Dollar Spot Disease Of Turfgrass

R. M. Endo
Department of Plant Pathology
University of California, Riverside

1. First of all, what is "dollar spot"?
   Dollar spot is a fungal disease of turfgrass caused by the fungus *Sclerotinia homeocarpa.* Its name stems from the fact that the areas of turf that are affected usually are about the size of a silver dollar.

2. What is the fungus like?
   The fungus is active only in the form of threads; it does not produce asexual or sexual spores in the U.S. (they have, however, been reported from England). The fungus attacks the leaf blades primarily, the stems occasionally, and the roots rarely.

3. How effective is nitrogen fertilization in controlling dollar spots?
   Complete control of dollar spot is not obtained; control is usually evident as reduced numbers of diseased spots per unit area and less severely diseased plants. Percentage reduction of dollar spot-affected areas will vary depending upon the form of nitrogen applied, the amount and frequency of its application, etc. Numerous turfgrass researchers have noted and commented upon this relationship. Unfortunately, no general guide lines are available in regard to nitrogen fertilization; the usual recommendation is simply to maintain "adequate" nitrogen fertilization. At UCLA we secured 76% reduction of dollar spot with NH_4NO_3 applied biweekly at the rate of 1.25 lb. per 1000 sq. ft.

4. How does nitrogen fertilization control dollar spot?
   The *Sclerotinia* fungus is a weak parasite that possesses only a very limited ability to cause disease. This can be shown readily by placing threads of the fungus suspended in water upon vigorously-growing, young, green leaves and old, yellow leaves; only the latter are infected by the fungus. However, the fungus can be encouraged to infect the vigorously-growing, young leaves if a nutrient food base is provided either as guttation fluid, as a bit of *Sclerotinia*-infected tissue, or as a drop of dilute sugar solution. We, therefore, believe that adequate nitrogen fertilization reduces the number of dollar spot-affected areas because the yellow, aged leaves which function as a food base are kept at a minimum.

The Role Of Guttation Fluid In Fungal Disease Development

R. M. Endo
Department of Plant Pathology
University of California, Riverside

1. ***What is guttation fluid or guttation water?***
It is the fluid exuded from the fixed, open stomata located at the tips of the grass blades or from the clipped ends of the grass blades, under conditions of high root pressure. It must not be confused with dew.

2. ***Why conduct research on guttation fluid?***
Diseases of turfgrasses are unusual in two respects. First, there are more damaging foliage diseases of turfgrass that are caused by fungi that grow and spread exclusively by fungal threads than of any other crop (eg. Dollar spot, Brown patch, Redthread, and Greasy spot). The important foliage diseases of most crops are caused primarily by fungi which produce spores. They grow and spread following thread development from wind or water disseminated spores. This is not surprising since gungal threads are very delicate, easily injured, and dependent upon readily available nutrients, whereas spores are survival structures that are adapted for widespread dissemination and carry their own internal supply of nutrients.

Secondly, the fungi that grow and spread by fungal threads tend to infect the uppermost leaf blades of turfgrass, usually at or near their tips. If moisture were solely responsible, infection should be more severe on the lower leaves since moisture is retained there for the longest periods. A satisfactory explanation for both fungal behavior responses could be postulated if guttation fluid contained nutrients which promoted rapid thread growth and infection by the individual fungal threads. This possibility was therefore investigated.

3. ***How was guttation fluid produced and collected for experimental purposes?***
Two methods were used. In the first, a glass rod was rolled over turfgrass sod during early morning. The grass blades were covered with drops of guttation fluid and dew which adhered to the surfaces of the glass rod. The dew-guttation fluid mixture was collected, sterilized by filtration, and stored frozen until used for experimental purposes. Collections were made only when guttation was common and dew formation was scant or rare.

In the second method, grass seeds were first surface sterilized, then grown as seedlings in the laboratory under artificial lights in sterilized vermiculite moistened with nutrient solution. Drops of guttation fluid were collected, sterilized by filtration and stored frozen until used.

4. ***What indications were obtained that guttation fluid may favor the disease development of fungi that grow and spread primarily by means of fungal threads?***
If drops of guttation fluid or water are placed on leaves of Seaside bentgrass and threads of the dollar spot fungus are added to the droplets, the threads in guttation fluid grow sparingly to well and cause a variable amount of infection, whereas the fungal threads in water grow very sparingly and fail to cause infection. Similar results were obtained with whole plants in the greenhouse and with the fungus Rhizoctonia solani whichcauses the brown patch disease.

The following experiment is a very simple method of verifying the importance of guttation fluid. Place a moistened 2-to 4-inch plug of turfgrass in a closed plastic bag in order to induce guttation. Place a single leaf infected with the dollar spot or brown patch fungus on the surface of the plants and observe in 12 to 24 hours. The threads will emerge from the infected leaf and will usually grow out over the surface of the plants in all directions. When the threads encounter a drop of guttation fluid, an increased amount of mycelial growth may occur followed, in most cases, by successful infections of the leaf blade (see Fig. 1). A bridging of fungal threads from guttation fluid droplet to guttation fluid droplet occurs very frequently.

5. ***What evidence was obtained that guttation fluid may also favor the development of fungi that produce spores?***
When bentgrass seedlings were sprayed with spores of Helminthosporium sorokinanum suspended in guttation fluid (collected from bentgrass) or water, plants sprayed with the spore-guttation fluid developed very severe symptoms on 99% of the plants in 2-4 days: abundant spore production occurred in 4 days, and nearly all seedlings were dead after 6 days. Plants inoculated with the spore-tapwater suspensions developed water soaking, yellowing and necrosis on 10% of the seedlings in 6 to 7 days: a slight amount of sporulation occurred in 9 days, and all plants survived even after 14 days.

The increase of infection and disease severity resulted from a guttation fluid induced acceleration and increase in spore germination, infection structure formation (to be explained in the next question and answer), percentage infections, and subsequent development and spread of the fungus in the infected tissues.

6. ***What are infection structures and why are they important?***
Infection structures are club-shaped structures that are produced by the fungal threads that arise from the germinating spore (see Fig. 2A). These club-shaped swellings, called appressoria, are necessary for the process of plant infection. They accomplish this by attaching themselves to the surface of the leaf (see Fig. 2B) by means of a sticky glue-like substance which they secrete. These appressoria take up the back pressure exerted by the fungal

threads which form where the appressoria contact the plant surface. The mechanical pressure exerted by these thread s results in the formation of a hole through which the fungus penetrates the plant cells. The increased formation of these structures by gutta tion fluid, therefore, results in increased infection and disease.

7. Why does guttation fluid favor an increase in disease?
Because they may contain small amounts of plant nutrients which give increased growth of the fungi.

8. Has this relationship between guttation fluid and fungal disease development been demonstrated for any other grass besides bentgrass?
No. Variable results were obtained with guttation fluid collected from barley.

9. Did all samples of bentgrass guttation fluid increase infection and disease development?
No, not all samples, and we are not sure of the reason for the variability. We suspect that fertilization may influence the nutritional content of guttation fluid and that bacteria and yeasts, which occur naturally on the leaf surfaces, may use and deplete the nutrients very rapidly.

10. When sbouldan attempt be made to controlguttation fluid in order to reduce disease development on bentgrass?
Probably only when disease is developing actively in the field on high maintenance turfgrass areas such as golf greens and bowling greens.

11. How can guttation fluid be removed?
By poling, mowing or irrigating greens in early morning to remove or dilute the guttation fluid to the point of ineffectiveness.

FIG. 1. GUTTATION FLUID DROPLETS EXUDING FROM THE LEAF TIPS OF SEASIDE BENTGRASS. NOTE FUNGAL THREADS OF THE SCLEROTINIA FUNGUS THAT HAVE COLONIZED THE DROPLETS AND ARE GROWING AS THREADS FROM DROPLET TO DROPLET.

FIG. 2. SPORES (ASEXUAL) FUNGAL THREADS AND INFECTION STRUCTURES OF THE HELMINTHOSPORIUM FUNGUS THAT CAUSES "MELTING-OUT" OF BLUEGRASS. A) THE CIGAR SHAPED STRUCTURES DIVIDED INTO CELLS ARE THE WIND-DISSEMINATED SPORES; THE TUBE ARISING FROM IT IS THE FUNGAL THREAD; AND THE SWELLING AT THE END OF THE TUBE IS THE APPRESSORIUM. THE TUBE ARISING FROM THE END OF THE APPRESSORIUM IS THE STRUCTURE THAT PENETRATES THE PLANT CELLS. B) THE PEAR-SHAPED APPRESQ SORIUM IS FIRMLY ATTACHED TO THE LEAF SURFACE BY A STICKY MATERIAL. THE FUNGUS HAS PENETRATED THE LEAF AND HAS FORMED A SWOLLEN STRUCTURE WITHIN THE EPIDERMAL CELL; ADDITIONAL FUNGAL THREADS HAVE FORMED FROM IT.

Turfgrass Adaptation In California

V. B. Youngner
University of California, Riverside

Two criteria of foremost importance to proper selection of tutfgrass varieties are adaptation to climate and adaptation to specific turf use. Poor quality turf often may be traced to a failure to consider one or both of these. Climatic factors modify growth of a grass plant so that such turf characteristics as density, texture, toughness and rooting depth will not necessarily be the same in different climates.

A variety not only must be able to grown in the climate of an area but it must be able to develop the required turf quality under the specific maintenance practices and use characteristics to which it will be subjected. Kentucky bluegrass, for example, may be excellent for athletic fields in one climatic area and in another locality be valuable for home lawns but unsatisfactory for athletic fields.

In the table that follows are presented variety recommendations for the principal types of turf within the major California climatic zones shown on the accompanying map. Before a final variety selection is made local climatic modifications, exposure, soil and anticipated maintenance level must be considered also. While varieties are given in order of preference in each climatic zone-turf type list, selection will be affected by the above factors. In some cases several species or varieties may be comparable in adaptation and value so selection will be on the basis of color, blade width or other characters.

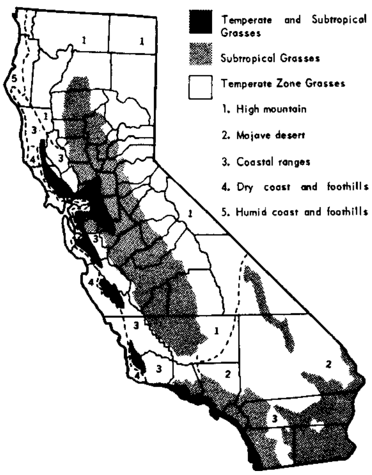
Variety recommendations for Kentucky bluegrass and red fescue are not given because there is insufficient information available on differential climatic adaptation of the many strains. Merion, Newport, Prato, Windsor and Park are acceptable varieties and may be used wherever Kentucky bluegrass is recommended. Two or three of these may be combined to provide a somewhat broader adaptation than a single strain may have.

Illahee, Ranier and Pennlawn are equally satisfactory varieties of red fescue. These may be mixed with Kentucky bluegrass varieties wherever both species are recommended. Chewings fescue may be used in place of red fescue but will produce a poorer quality turf.

Redtop is not listed but may be grown with little difficulty wherever the bentgrasses are recommended. However, redtop is of doubtful value for any type of turf, hence, receives no recommendation.

Annual ryegrass may be used as a temporary turf in temperate zones 1, 4 and 5 and as a winter grass on warm season turfgrasses in all other zones.

As experience with certain types of turf on some climatic zones, eg. bowling greens in temperate zones 1 and 2, is lacking, recommendations are based on knowledge gained from similar types of turf in that zone or from other climatic zones.



CALIFORNIA TURFGRASS CLIMATIC ZONES

ADAPTABILITY OF GRASSES FOR VARIOUS TYPES OF TURF

TURF TYPE	TURFGRASS CLIMATIC ZONE						
	SUBTROPICAL	TEMPERATE SUBTROPICAL	TEMPERATE ZONE 1	2	3	4	5
LAWN5	Bermuda[2] Tifgreen Tifdwarf[3] Sunturf Zoysia Emerald Matrel'la Dichondra St. Augustine Tall fescue[4] Ken. bluegrass	Ken. bluegrass Dichondra Bermuda Tifgreen Sunturf Zoysia Emerald Matrella Tal I fescue	Ken. bluegrass Red fescue Tall fescue Highland bent Meadow fescue	Ken. bluegrass Tall fescue Bermuda[5] Tifgreen	Ken. bluegrass Tall fescue Red fescue Dichondra Meadow fescue	Ken. bluegrass Red fescue Highland bent Tall fescue Dichondra Meadow fescue	Ken. bluegrass Red fescue Highland bent Astoria bent Tall fescue
PARKS	Bermuda Santa Ana Tifgreen Tifway Tall fescue Bahiagrass Zoysia St. Augustine	Tall fescue Bermuda Santa Ana Tifgreen Tifway Sunturf Ken. bluegrass Meadow fescue	Ken. bluegrass Red fescue Tall fescue Ryegrass Perennial	Tall fescue Ken. bluegrass Bermuda Santa Ana Tifway	Ken. bluegrass Tal I fescue Red fescue Bermuda[5] Santa Ana Tifway	Ken. bluegrass Tal I fescue Meadow fescue Red fescue Ryegrass Perennial	Highland bent Astoria bent Ken. bluegrass Tall fescue Red fescue
PLAY-GROUNDS	Bermuda Santa Ana Tifway Sunturf Tifgreen Tall fescue Bahiagrass Zoysia	Tall fescue Bermuda Santa Ana Tifway Ken. bluegrass	Ken. bluegrass Tall fescue Red fescue Ryegrass Perennial	Tal I fescue Bermuda Santa Ana Tifway	Tal I fescue Ken. bluegrass Meadow fescue Bermuda Santa Ana Tifway	Tal I fescue Ken. bluegrass Meadow fescue Red fescue Ryegrass Perennial	Ken. bluegrass Red fescue Highland bent Tal I fescue
ATHLETIC FIELDS	Bermuda Santa Ana Tifway Sunturf Tall fescue	Tal I fescue Bermuda Santa Ana Tifway Sunturf	Tal I fescue Ken. Bluegrass	Tall fescue Bermuda Santa Ana Tifway	Tal I fescue Ken. bluegrass Bermuda Santa Ana Tifway	Tall fescue Ken. bluegrass	Tall fescue Ken. bluegrass Red fescue
GOLF GREENS	Creeping bent Congressional Old Orchard Seaside Penncross Bermuda Tifgreen Tifdwarf	Creeping bent Congressional Old Orchard Seaside Penncross	Creeping bent Congressional Old Orchard Seaside Penncross	Creeping bent Congressional Old Orchard Seaside Penncross Bermuda Tifgreen	Creeping bent Congressional Old Orchard Seaside Penncross	Creeping bent Congressional Old Orchard Seaside Penncross	Creeping bent Seaside Penncross Congressional Old Orchard
GOLF FAIR-WAYS	Bermuda Common Tifway Santa Ana	Bermuda Common Tifway Santa Ana Ken. bluegrass	Ken. bluegrass Red fescue Highland bent	Ken. bluegrass Bermuda Santa Ana Tifway Common	Ken. bluegrass Red fescue Highland bent Bermuda Common Santa Ana Tifway	Highland bent Red fescue Ken. bluegrass	Highland bent Red fescue Ken. bluegrass
GOLF TEES	Bermuda Santa Ana Tifway Tifgreen Sunturf Zoysia	Bermuda Santa Ana Tifway Tifgreen Sunturf Ken. bluegrass	High land bent Red fescue Ken. bluegrass	Bermuda Santa Ana Tifway Ken. bluegrass	Bermuda Santa Ana Tifway Tifgreen. Ken. bluegrass Red fescue	Highland bent Red fescue Ken. bluegrass	Highland bent Astoria bent Creeping bent Seaside Old Orchard Red fescue Ken. bluegrass
BOWLING GREENS	Creeping bent Congressional Seaside Penncross Old Orchard Bermuda Tifgreen Tifdwarf	Creeping bent Congressional Seaside Penncross	Creeping bent Congressional Seaside Penncross	Creeping bent Old Orchard Seaside Congressional Bermuda Tifgreen	Creeping bent Congressional Seaside Penncross Bermuda Tifgreen	Creeping bent Congressional Seaside Penncross	Creeping bent Seaside Penncross Congressiona'

1 Grasses are listed approximately in order of preference for a given use.

2 **Common** bermudagrass may be substituted wherever hybrid bermudas are listed. However, resulting turf will be of lower quality.

3 **Tifdwarf** has had limited testing in California therefore specific adaptation and use are not known. Suggested for trial because of its unique characteristics.

4 **Tall** fescue may be used wherever a durable, pest free, all year turf is desired and coarse texture is acceptable. Alta, Kentucky-31 and Goar's are of equal value. Tall fescue should not be mixed with other grasses.

5 Because of the long dormant period overseeding with cool-season grasses for winter turf may be required if bermuda is used in temperate zones 2 or 3.

The Economics Of Turfgrass Sprinkler Irrigation

Dr. Wm. W. Wood, Jr. [1]

At first glance the title, Economics of Turf Grass Sprinkler Irrigation, appears to be a rather simple proposition. Perhaps it is. However, there are some complications associated with this subject which makes analysis from an economic point of view a bit more complicated.

The difficulty in making an economic analysis of sprinkler systems for turfgrass arises from the fact that there is not a product produced to which a market or demand price can be attached. We know there is a derived demand for turfgrass arising from its use as a vehicle towards other ends. However, it is exceedingly difficult if not impossible to attach a price to the various types of turf conditions that might 'result from various cultural practices or which might be acceptable to the consuming public. As a result of this restriction, the economist is somewhat limited in his approach to making an analysis of turfgrass sprinkler irrigation economics.

There seem to be two avenues of approach of economic analysis in this subject matter area. The first and perhaps most important as far as this group is concerned is the selection of a sprinkler irrigation system from among alternatives that may be available. This in economic terms is a matter of comparative analysis in which different systems are compared as to their cost and their life expectancy in providing the type of service that is satisfactory. The second type of analysis that presents itself is that essentially of cost accounting in which the object is to minimize the operating cost on a system which has already been installed and is in use. In this instance it is primarily an accounting procedure whereby management obtains the maximum amount of information with which to make decisions. The remainder of my comments will be directed towards a comparative analysis approach prior to installation of irrigation systems.

Here it may be well to make a confession. As far as the economist is concerned he is highly dependent upon both the turf user or turf manager and the irrigation system supplier for rather accurate information before an analysis can be made. From the standpoint of turf management or the user of turf, there must be a rather explicit specification as to the quality or condition of turf that is required. Since a market price cannot be attached to the turf product, the difficulties which arise are rather important. The turf user or the manager of the turf area must be able to specify the minimum condition of turf which will be satisfactory as well as any restrictions as to when turf must be available to the user. For the sprinkler system supplier there must be a specification as to what a given system will do in terms of providing the type of service and the distribution of water that may be necessary. It is my impression that neither of these conditions have been adequately met by your industry.

The tendency in comparing alternative sprinkler irrigation systems is to view a least cost system as the feasible one. In actuality however, the least cost system is the feasible one only if it also meets the conditions of turf that are required and secondly, that the system will in fact perform at a given level or standard.

There are of course a number of items that we can mention that should be considered by both the turf manager and the installer. These include the price and amount of water available, the time schedule available for water application, the management that may be available to properly utilize irrigation facilities, the amount and type of labor available as well as the obvious conditions of topography and climate. Before discus sing each of these categories however, some mention should be made of the economic theory that is involved in the type of analysis that I propose.

As you are probably well aware the advantages or disadvantages of alternative systems tends to center around the question of substituting capital for labor and water. In economic terms this means substituting fixed for variable costs. Thus a manual system which requires a very small initial installation cost will incur substantial variable costs in the form of wages for labor and quite probably excess water. A system which is fully automatic may require a substantial initialinvestment and therefore a large annual fixed cost but may require no manual labor or wages for labor and likewise may have the lowest excess usage of water. Here again fixed cost in terms of increased or higher installation charges may be substituted for a lack of available labor, for a lack of management ability or attention, or for that matter, it may be substituted for a lack of available hours for application of required water.

The usual economic analysis which seems to be prevalent in the sprinkler irrigation industry is what is commonly termed a payout period analysis. This sort of analysis can be found in much of the recent literature on the economics of sprinkler irrigation of turf. I would prefer not to use this sort of analysis for a number of reasons, Principally these are that it ignores the cost of capital in the analysis and that it does not distinguish between fixed and variable cost which can have a considerable significance in terms of available capital over a period of time. The system which I would propose rather than payout period is one of analyzing the annual total costs of alternative systems. This type of analysis however, requires that the life expectancy of the total system or components of the system be determined and likewise it assumes a given rate of return on investment. However, it does permit the amortization of both principal and interest over the expected life of the irrigation system.

For each system analyzed, information must be determined as to the amount of water used, the cost of that water, the amount and cost of labor necessary to utilize the system and the expectedamount for repairs and maintenance to the system. The fixed costs for the system are the amortized cost of initial installation in terms of depreciation of the system for the recapture of capital and interest on the capital that is invested in the system. The combination of fixed and variable costs then determine the annual total costs of operating alternative irrigation systems.

The important categories which must be considered in making any comparative analysis of irrigation systems, as specified above, include items for which there may not be accurate data and for which a subjective evaluation may be necessary. However,

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[1] Extension Ecoomist. University of California, Riverside.

this should not be used as an excuse not to consider each of the categories named.

Water

The cost of water per hundred cubic feet or per thousand gallons must be determined as well as the availability of water in total amount and the amount of pressure that may be available during times when irrigation is necessary. Likewise there must be a comparison ofaltemative systems in terms of some sort of water factor which will represent the amount of excess water which must be applied by a given system to meet the minimum amount necessary to cover plant or turf evapotranspiration.

Labor

The cost of labor per hour in terms of wages paid plus all other costs such as social security and unemployment insurance must be calculated. In addition, consideration should be given to the ability to fully utilize labor in a turf area, Labor is rapidly becoming a fixed cost for many operations in which you ate not able to hire a few hours of labor but must hire an individual on a full time basis. In this instance the cost of labor for operating a sprinkler irrigation system must be calculated not only on the hours devoted to operating the system, but the total hours for which payment must be made. If labor costs are replaced in part by capital, then alternative uses of that labor must be determined. Consideration must likewise be given to the hours for which irrigation applications can be made. If applications are made at night, then there may be an added cost in terms of labor availability.

Management

This is perhaps the most difficult of all variables to be considered but nevertheless perhaps one of the most important. I think each manager or owner of a turf area must honestly and objectively evaluate the intetest and ability to provide the type of management necessary to properly utilize the various sprinkler irrigation systems. It becomes obvious that a fully automatic system requiresless management interest and ability than does a pull hose system in which the times and length of irrigation must be determined for each application. Perhaps the most feasible approach is to use a scale of 0 to 10 to evaluate or rate management in terms of its availability for operating a sprinkler irrigation system. In this scale a rating of 0 would indicate no management availability and would dictate a fully automatic system; conversely a rating of 10 would indicate management availability to handle any type of system and therefore management should not be a serious consideration among alternative systems.

Other considerations for proper economic analysis of course must include topography, climate, and types of turf used. However, these are less difficult to analyze on an individual basis and do not particularly lend themselves to generalization in the present context. In the final analysis it must be admitted that an economic analysis is significant only insofar as cost and price are involved. If, because of requirements of a greens committee or someone else who has some authority over management or management itself requites a certain condition of turf or a certain application of water or a certain cash expenditure on an annual basis, it may well be that these particular restrictions will be more important than total annual cost and will in and of themselvesdictate which among comparative sprinkler systems should be utilized.

CALIFORNIA TURFGRASS CULTURE
Department of Agronomy, University of California
Riverside, California 92502
Editor, Dr. Victor B. Youngner

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