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Brown Patch of Turfgrass Caused by Rhizoctonia Solani Kiihn

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Rhizoctonia solani Kiihn was first identified as a turf pathogen in 1916[29/] but the story leading to its identification began in 1885 in South Manchester, Connecticut. In that year Mr. J. B. Olcott started selecting individual grass plants of beauty and quality. He increased his selections vegetatively and planted them in a turf garden.[28/] Mr. Olcott favored red fescue and one red fescue in particular was his favorite. This he increased and planted as the principal lawn about his home. Fred W. Taylor, of Philadelphia, became enamored of this pure sward of fescue and about 1912-13 purchased it, lifted the sod, and used it around his home in Highland near Philadelphia. The grass that had been a beauty in Connecticut languished in the heat of Philadelphia and in the summer of 1914 began to die in large patches.

Mr. Taylor went to Washington for help and got the assistance of C. V. Piper and R. A. Oakley of the Arlington turf gardens and by 1916 Piper identified the cause of the brown patches as the fungus *Rhizoctonia solani.*

That turf was killed by fungal diseases was not immediately accepted, and as late as 1926 Dr. Monteith found it necessary to offer evidence to convince golf course superintendents that the disease was not caused by spiders; that the web-like threads were the mycelium of a fungus.[26/]

Today *Rhizoctonia* is the number one turf enemy in the United States according to a survey of turfgrass diseases by Dr. Charles Gould.[14/] It affects over 100 species of grass including all of the turfgrasses,[38/] and is an important disease in all areas of the country save the cool humid Pacific Northwest.

Rhizoctonia solani Kuhn names a broad group of fungi the mycelial threads of which appear alike in the vegetative state. On occasion collected strains have fruited and produced sexual spores. These strains have generally been classified as *Thanatephorus cucumerus* (Frank) Donk. *(Pellicularia filimentosa* (Pat.) D.P. Rogers) a basidiomycete. Recently however, isolates classed as *Rhizoctoni* have fruited and found to be ascomycetes. Thus while the members of *Rhizoctonia* are grouped together because of similar vegetative structures the group may at present, contain wholly unrelated members. Turf brown patch may be caused by closely related organisms but we cannot assume we are dealing with a single true species as some early investigators did.

Rhizoctonia solani (ot rhizoc for short) is present as part of the flora of most soils. While acid soils have been considered to favor *Rhizoctonia,*[38/] there is no lack of inoculum in basic soils and the fungus grows at a wide range of pH values.[26/] The fungus forms small hard bodies of compact mycelium, *sclerotia,* which survive unfavorable seasons and "seed" new infections.

The sclerotia are brown to blackish flattened discs of about 1/32 – 3/32 of an inch in diameter and may often be found embedded in the plant tissue or they may be in the soil. The fungus may also survive for long periods in the soil as a saprophyte living in dead clippings or thatch and in tests has survived 2 years in dry soil.[40/] When there is an active infection, clippings which miss the catcher provide a source of new infection for 4 months or more.[35/] Top dressing applied to greens may also be a source of infection.[23/] In addition, *Rhizoctonia* is seed borne[20/] and may be sown with the seed unless the seed is treated. Seed borne inoculum is especially important as seedlings and young grass plants are very susceptible to injury.

The many strains of *Rhizoctonia* may vary as to the plant infected, the severity of the disease caused, the temperatures at which they are pathogenic, whether they grow down in the soil or on the soil surface, etc. A virulent strain however, is likely to infect several grasses and Atkins for example found he could cross inoculated rhizoc strains from tall fescue and bermudagrass.[3/]

Over the years the most attention has been given to brown patch on bentgrass putting greens. There are several reasons for this. First is the high economic value of the turf. Second is great severity of the disease due to the short, frequent mowing and the high levels of soil moisture. Thirdly, is increased susceptibility of bentgrasses, so the disease may appear on greens in years when other turf is not visibly affected.

In 1930 Dickinson gave a detailed description of the response of Rhizoc on greens to temperature conditions, and offered evidence that the occurrence of brown patch was completely predictable from weather records. When warm temperatures dropped to the 60's, sclerotia germinated and produced short mycelial threads about 1/2" in length. Growth remained static in this condition, but if a warming trend then followed, the mycelia began to grow

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and became infective from the mid 70's to the mid 80's. While activity of the fungus practically stops above 90°, the higher temperatures may weaken turf so that damage is more severe when temperatures fall again to the 80's. A drop to 60° followed by a rise to 75-80° could result in the appearance of the smoke ring within three hours. Dickinson offered evidence that the disease could be checked at this stage by poling, to break up the mycelium mechanically.

A study of this kind suggests that one is dealing with a fungus responding to a limited range of growth conditions, and it may be that a single ecotype comes to predominate in a large geographical area. At the same time many strains exist and one has been described from California which is pathogenic at temperatures near freezing and can cause brown patch in January, particularly on autumn seeded turf. [24/11/] Variability is also indicated by Endo's work. Of 34 isolates he made of rhizoc, 4 were capable of infecting bentgrass. [11/]

Studies of brown patch have been made predominantly on putting green turf in the Northeast and the pictures and descriptions published have not always fitted our experiences in the dry regions of the Southwestern U.S. Not only are there several strains but the disease appears to have more than one form and I should like to suggest some possible differences.

In the Northeast, *Rhizoctonia* is described in the literature as most damaging on putting greens during hot humid weather. In the spring, with warming temperatures, the sclerotia germinate and are likely to first grow as soil saprophytes which reach a high level of activity in two to four days at favorable temperatures. [6/, 31/, 34/] Development of brown patch is favored by soil nitrogen and by water levels in the lower ranges of availability. [27/] With warming temperatures the fungus may infect first roots, then stolons and leaves. The fungus enters more readily through cut ends of leaves. Rowell [31/] found in a laboratory experiment that uncut grass inoculated with *Rhizoctonia* remained fairly free of the disease while cut grass was severely damaged. The fungus enters at the tip of the cut blade, through stoma, or by penetrating the leaf, and progresses downward to the center of the plant. Moisture from guttation water contributes to rapid spread of the disease, the mycelium bridging from one drop of water to another. [35/] The guttation water (so-called dew) provides not only a moist medium at the cut ends, but may contribute nutrients and may be capable of inactivating the fungicide PMA. [31/] With continuing moist, warm conditions, the disease results in a brown patch of infected plants several inches to several feet in diameter. The edge of the patch may be bordered, especially in the early morning, with a band of dark smoky or purplish color where the fungus is actively destroying the grass. The patch enlarges as much as several inches a day. The collapsed leaves containing masses of mycelium, dry and turn brown.

An early observation of the importance of moisture in the spread of *Rhizoctonia* during the intectious stage was made on a lakeside golf course in New York State. [32/] Six men each mowed 3 greens starting regularly at 7:00 a.m. As an aid to mowing, "dew from the lake" (guttation water?) and worm casts were poled from each green before mowing. The six greens mowed first each morning were free of *Rhizoctonia,* the six mowed third were seriously affected. Early morning poling, dragging, or hosing of greens was early recognized to assist in *Rhizoctonia* control. [13/]

In a study of brown patch in Rhode Island, Shurtleff [35/] found he could control *Rhizoctonia* with a series of three carefully timed mercurial sprays. When spring soil level temperatures were over 60° and the humidity over 98% sclerotia began to germinate. At that time he irrigated the turf and 48 hours later sprayed it with mercuric chloride. The irrigation and spray were repeated three times at weekly intervals, at the end of which time the disease potential was minor. This proposed program has not been widely used.

In the Southern states a program such as the above is not likely to be effective. In the Southwest the appearance of brown patch may also be different. The following paragraphs explore the basis for these differences.

The usual seeded bentgrass green is a patchwork quilt of lighter and darker green grasses and in the winter some of the patches become reddish. I had often pointed this out to students as a possible genetic difference in anthocyanin producing ability. When Aage Anderson was working with the turf program at Davis, his training as a plant pathologist led him to question my statement. He had often seen such reddish color associated with disease. During the winter of 1961-62 he examined many such reddish clones and in every case found the grass infected with *Helminthosporium*. At the same time he looked at many samples of green bentgrass for comparison. On a very large percentage of these samples he found Rhiz *octonia* to be active. On these plants emerging roots and new roots became necrotic and died at 1/2 to 1 inch of length. While we noted the correlation between the presence of *Rhizoctonia* and the necrosis of roots we did not establish whether the damage was caused by the fungus, or whether the fungus was systemic in the roots.

Of the 34 isolates of rhizoc that Endo obtained from crowns of grass only 4 were pathogenic to bentgrass seedlings. [11/] Sherwood and Rindberg found evidence that rhizoc produced [33/] toxins and Kerr [19/] presented evidence these toxins might cause root necrosis. Thus we may have been seeing root injury from toxins produced by saprophytic strains of *Rhizoctonia* growing in the thatch or on the dead sheath bases.

We had been assuming on the basis of studies in the literature [39/] and on the basis of our own observations that bentgrass re-established a new vigorous root system every fall and winter when soil temperature favored root growth. Thus it was disappointing to find a summer disease damaging the root system even in the winter.

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Hearn[19/] found in Texas that rhizoc there was also active from September to January though it caused no injury at that time. *Rhizoctonia* persisting until the warming weather of spring, infected roots, then later stolons and leaves.

On St. Augustine which grows vigorously at 80° F. and above, *Rhizoctonia* is infectious at lower temperatures.[17/] In Southern U.S. it appears in the spring and fall when nights are cool and during mild spells in the winter. The vigor of St. Augustine is low at such times.

In the Southern states then, it appears *Rhizoctonia* is present even in winter and new infections start not only from germinating sclerotia but from the old growths which carry over. Thus we question that Shurtleff's program would be as effective in the South as in Rhode Island.

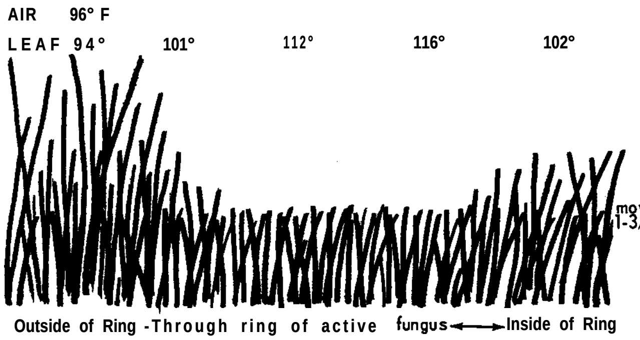
The classic description of the dead patch of grass with the smoky ring of active infection to the outside describes a leaf infection which is readily stimulated by presence of surface water. In the dry southwest formation of "dew" or at least its persistance during the early morning hours is less common in the summer and rhizoc in this classic form may occur only infrequently, and only under the short mowing and high moisture on putting greens.

Rhizoc is more commonly seen in the southwest in a second form which appears to have a more prominent effect on the root system.

As the disease appears in Davis, fungal growth begins during cool weather, moving outward in a circle from a center of infection, without visibly damaging the grass. Initial growth may be saprophytic, or at too low a rate to be damaging. As the weather warms, the fungus, which has moved out from its center of infection, becomes active by pathogenic damaging the grass in the form of a ring. Grass in the center of the ring appears fairly normal and the fungus does not move back into this area. Damage seems to be to the root system as the ring of grass which turns brown and dies usually dies from desiccation due to a root system unable to supply normal amounts of water. Frequent sprinkling or sprinkling and syringing during the period of infection may keep the grass green and alive.

It seems to me there are two forms of disease caused

FIG. 1 TEMPERATURE AND HEIGHT OF BLUEGRASS ACROSS AN INCIPIENT RHIZOCTONIA INFECTION 7 DAYS AFTER MOWING.



by *Rhizoctonia* and differences between them may be summed as follows:

Northeast Leaf Infection	Southwest Root Infection
Usually a leaf infection with mycelium visibly infecting the leaves when conditions are favorable for the disease.	Primarily a root or crown infection.
Produces a dead brown patch.	Produces a brown ring (rings may coalesce).
Leaves usually die from fungal invasion.	Leaves likely to die from desiccation.
Disease travels in moist air from cut leaf to cut leaf (as well as in soil and thatch).	Disease travels in soil or thatch.

The second type of infection has been observed in the field rather than studied in the laboratory. Laboratory study is needed and there are some unanswered questions about the deatils of the root type infection that need to be answered. It may be caused by the same organism as the leaf infection but growing under limited conditions of nutrition or moisture so that it does not reach the leaf infection stage. It may be caused by a different strain with a different habit. For example, Endo[12/] found of several isolates that the faster growing were the more damaging. The possibility exists that it may result from a complex of saprophytic strains of rhizoc growing on the dead sheath bases and producing toxins which limit the growth of roots. Or it may result from all of these at one time or another. That toxins may play a part is suggested by the increased infection at low soil water levels.

Activity of organisms which injure roots such as *Rhizoctonia* can be detected before the appearance of brown grass. The reduced root system and attendant water stress provide clues. In the early morning, areas of infection may appear as areas where there is no dew (guttation water) while surrounding grass is covered. Infected areas fail to grow as rapidly after mowing as the healthy grass. At 2:00 - 4:00 p.m. infected areas may appear bluish or greyish due to water stress. At the same time water stress results in higher temperatures so the infection may be felt as a hot spot by running the hand over the grass. Temperature effects are illustrated in Figure 1 along with reduced growth and height accompanying water stress. Due to higher midday leaf temperatures I found I could photograph infected areas at midday with increased clarity by using infrared film.

Reduction and control of *Rhizoctonia* can be effected both by cultural practices and chemical sprays. Among the cultural practices importance of dew removal before 7:30 a.m. has already been discussed.

Bloom and Couch[5/] explored the effects of fertility on *Rhizoctonia* infection in greenhouse tests. They recommend a normal level of N with balanced P and K. When N in their tests was low relative to P and K, the disease

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was less severe; but if N was high relative to P and K, severity was increased. When N was low, pH was of little effect; but the disease was favored by alkalinity at high N and acidity when N was in balance.

Hearn [16] found excess N was more damaging if applied in the ammonium form.

Data from our field studies are given in Table 1.

Table 1. Incidence of Rhiroctonio on 'Seaside' bentgrass os affected by management. Davis, 1963.

Treatments	High N	Medium N	Low N	Total
	Mowing Treatments Summed			
5 X week irrigation	35.2	30.5	51.1	116.8
1 X week irrigation	53.8	53.2	64.6	171.6
	Irrigation Treatments Summed			
5 X week mow	55.6	48.2	63.4	167.0
1 X week mow	33.3	35.4	52.3	121.0
Total	88.9	83.6	115.7	288.2

In this field experiment P and K levels were adequate. Low N turf was badly starved and high N provided in the neighborhood of 2# of N per 1000 sq. ft. per month. Nitrogen fertility was in interaction with mowing and irrigation practices and low fertility resulted in more disease, medium N the least. When irrigation was weekly there was a relatively high incidence of disease at all N levels, but when moisture was kept high, higher levels of nitrogen produced less disease.

More disease was associated with more frequent mowing. Further effects of mowing are given in Table II.

Table II. Effect of mowing height and aerification on Rhizoctonia disease in 'Seaside' bentgrass, Davis, 1961.

Date	May 31.1961	June13.1961	May 31. 1961	June 13,1961
Height of Mowing	Square feet of grass ingured by Rhizoctonia (50 sq. ft. per plot)			
	Replications 1 and 2	Replications **1 and 2 Aerified**	Replications 3 and 4	Replications 3 and 4
2"	1.9	3.5	1.4	1.2
l-3/8"	9.4	33.8	14.7	22.4
7/8"	6.2	21.4	15.3	21.4
1/2"	10.7	25.1	15.2	35.0
1/4"	16.1	47.3	17.6	26.3

These data were collected from plots originally mowed at 1/2 and 7/8 of an inch. In early May the height of mowing was changed to give the series of heights listed in the table. Shortly thereafter *Rhitoctonia* became prevalent in the plots. On June 3, two of the four replications were aerified.

In general there was more disease at the lower cuts. The injury was increased by aerification. This was probably an effect of drying. The plots were irrigated only weekly and when drying of the surface soil was increased by aerification, more plants with disease injured roots died from drying. It was necessary to increase the irrigation to twice weekly to prevent even greater killing of grass.

There has been speculation as to why brown patch is favored by drying of the soil when it is a disease requiring moist conditions. One hypothesis suggests that the reduced air movement in a moist soil results in a build-up of carbon dioxide which inhibits growth of the fungus. I favor the hypothesis that drying causes wilting and death of the root weakened plants and possibly, concentration of toxins to more damaging levels.

A recent experiment used additions of organic matter to the soil as a rhizoc control measure. [37] Oak sawdust added to the soil was twice as effective as PCNB (Terrachlor) in reducing rhizoc inoculum potential though rice hulls were without effect.

This can perhaps be attributed to fungitoxicity of lignin decomposition products.[21]

Use of disease resistant grasses assists control. The two grasses first released by the Arlington turf gardens, Metropolitan and Washington bentgrasses, were chosen for brown patch resistance. [26] Shurtleff has evaluated 23 grasses for their disease resistance, [36] and finds bents among the least resistant, fine fescues among the more resistant grasses.

All turf pathologists have considered thatch control important in reducing disease though experimental data is lacking. Endo [10] has noted that disease is generally associated with heavy or compacted soils. However, injury may be aggravated on sands because of their drouthy nature. We have also found *Rhizoctonia* increased on bluegrass when an herbicide had been used previously. [25] *Rhizoctonia* affected 23% of untreated turf while plots sprayed with one of five herbicides had an average disease incidence of 29% and ranged as high as 41%.

Summing the cultural factors, the best practices would include selecting a good grass variety, poling greens, using a balanced fertilizer at moderate rather than high levels, not lowering the mowing height after the seasonal temperatures have reached the 70's, and watching the irrigation to prevent drying of the soil or wilting of root damaged plants.

Compaction could well be relieved with an aerifier if accompanied by close attention to irrigation.

Bordeaux was the first chemical recommended for brown patch control [29] but repeated use resulted in copper toxicity. Experiments soon showed the mercurials to be of value [18] and they have been the basis of chemical control since. Their ability to act on the sclerotia makes them valuable in an early season preventative program.

Early season spraying with PCNB (Terrachlor) may also be used as a preventative program. PCNB is a

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fungistat which prevents the fungus from achieving full growth potential in the soil. However, PCNB is little effective once the disease becomes a leaf infection as in the Northeast. At high levels PCNB may cause yellowing of the grass

In the region where Rhizoc is a problem, use of a preventative spray should be added to the list of cultural practices to be followed.

For control, a 1:1 mixture of mercurous and mercuric chloride is used at 2 oz. per 1000 ft. 2/ in. 5-10 gallons of water. 6/ (Use goggles - do not use galvanized tanks.) At higher temperatures mercurous chloride (calomel) is used alone as it is less injurious to turf. Two ounces of Thiram and one-half ounce Semesan (active ingredient) was found an effective control by Bachelder and Engel.4/ (These chemicals are combined in Tersan OM). Couch et al /7 tested 22 chemicals and found that all reduced the severity of the disease but the grass made the most rapid recovery when the following were used: Tersan OM, Ortho Lawn and Turf Fungicide, Dyrene, Dithane M-22, Actidione-Thiram and Thimer.

The level of control from organic fungicides may decrease from year to year as the fungus builds up tolerance. In laboratory tests Elsaid and Sinclair /9 found Rhizoctonia becoming more and more tolerant of Captan, Dichlone, Maneb, PCNB, and Thiram. Thus the most effective program may be one which alternates organic with inorganic fungicides and which changes the organic fungicide from time to time,

As used, fungicides act on fungi growing on leaves and on the soil surface. The large reservoir of infection below the surface remains untouched. For this reason Lukens and Stoddard 22/ 23/ have investigated the injection of fungicide into the soil and report a deeper, heavier root system as well as rhizoc control for more than one season.

They have used Nabam (1:600) and oxyquinoline sulfate 1:1200) injecting into the soil at a pressure of 200 Ibs. per sq. in. about 12" deep and 4 feet on centers. Also they have drenched greens with oxyquinoline sulfate at 1 oz. per 16 gal. water to provide one pint per square foot.

While such drenches along with some new chemicals 1/ 2/ have given promise of Rhizoctonia control they have not been fully evaluated and it appears that Rhizoctonia is likely to remain the number one turf disease problem in the United States for some time into the future.

LITERATURE CITED

1/ Adams, Peter B. and Dr. Frank L. Howard. 1964 Progress report on methyl arsine oxide. Golf Course Rptt. 32(5): 22.

2/ Ashworth, L.J., Jr., B. C. Langley and W. H. Thames Jr. 1964. Long term inhibition of Rhizoctonia solani by a nematocide, 1, 2-dibromo-3-chlotoptopane. Phytopath. 54: 187-191

3/ Atkins, J. G. 1952. Forage crop Rhizoctonia cross inoculation tests. (Abstr,) Phytopath. 42: 282.

4/ Bachelder, Stephen and Ralph Engel 1963. 1962 turf fungicide trials. Park Maintenance 16(4): 38-44

5/ Bloom, J. R. and H. B. Couch. 1960. Influence of environment on diseases of turfgrasses. I. Effect of nutrition, pH, and soil moisture on Rhizoctonia brown patch. Phytopath. 50: 532-535.

6/ Couch, Houston B. 1962. Diseases of turfgrass. Reinhold Publishing Corp. New York. 289 + xiii pp.

7/ ————, L.D. Moore, and E.R. Bedford. 1962. Chemical control of Rhizoctonia brown patch of bentgtass. (Abstr.) Phytopath. 52: 923.

8/ Dickinson, L.S. 1930. The effect of air temperature on the pathogenicity of Rhitoctonia solani parasitizing grasses on putting green turf. Phytopath. 20: 597-608.

9/ Elsaid, H.M. and J.B. Sinclair. 1962. Adapted tolerance to organic fungicides by an isolate of Rhizoctonia solani. (Abstr.) Phytopath. 52: 731.

10/ Endo, R.M. 1960. Some common causes of turf failure in Southern California. Cal. Tutfgtass Cult. 10(3): 22.

11/ ———— 1961. Turfgrass diseases in Southern California. Plant Dis. Rptr. 45: 869-873.

12/ ————. 1963. Influence of temperature on rate of growth of 5 fungus pathogens of turfgrass and on rate of disease spread. Phytopath. 53: 857-861

13/ Fitts. O.B. 1924. Early morning watering as an aid to brown-patch control. Bull. of the Green Section U.S.G.A. 4(7): 159.

14/ Gould, Charles J. 1963. How climate affects our turfgrass diseases. Proc. of the 17th Ann. N.W. Turfgrass Conf. pp. 29-43.

15/ Hansen, A.A. 1959. Grass varieties in the United States. U.S.D.A. Agt. Handbook 170. 72 pp.

16/ Hearn, J.H. 1943. Rhizoctonia solani Kuhn and the brown patch disease of grass. Proc. Tex. Acad. Sci. 26: 41-42.

17/ Holt, Ethan C. 1963 Control of large brown patch on St. Augustine grass Golf Course Rptr. 31(5); 48-50.

18/ Keil, H.L. 1944. New fungicide developments for turf, Greens keepers Rptr. 12: 5-6.

19/ Kerr, A. 1956. Some interactions between plant toots and pathogenic soil fungi. Austral. J. Biol. Sci. 9: 45-52.

20/ Leach, CM. and Merle Pierpoint. 1958. Rhizoctonia solani may be transmitted with seed of Agtostis tenuis. Plant Dis. Rptr. 42: 240.

21/ Lingappa, B.T. and John L. Lockwood. 1962. Fungitoxicity of lignin monomers, model substances, and decomposition products. Phytopath 52: 295-299.

22/ Lukens, R.J. and E.M. Stoddard. 1961. Wilt disease of golf greens and its control with Nabam. (Abstr.) Phytopath. 51: 577. (See also Cal. Tg. Cult. 1960 #4).

23/ Madison, J.H. 1961. Rhizoctonia solani in relation to maintenance of golf courses. U.S.G.A. Green Sec. Jour. 14(4): 27-31.

24/ ———— L.J. Peterson and Thomas K. Hodges. 1960. Pink snowmold on bentgrass as affected by irrigation and fertilizer. Agron. Jour. 52: 591-2.

25/ ———— 1961. The effect of pesticides on turfgrass disease incidence. Plant Dis. Rptr. 45: 892-3.

26/ Monteith, John Jr. 1926. The brown patch disease of turf: its nature and control. Bull. of the Green Sec. U.S.G.A. 6(6): 127-142.

27 Papavizas, G.C. and C.B. Davey. 1961. Sparophytic behavior of Rhizoctonia in soil. Phytopath. 51: 693-699

28/ Piper, C.V. 1921. The first turf garden in America. Bull. of the Green Sec. U.S.G.A. 1(1): 23.

29/ ———— and R.A. Oakley. 1921. The brown patch disease of turf. Bull. of the Green Sec. U.S.G.A. 1(6): 112-115.

30/ Rogers. D.P. 1943. The genus Pellicularia. Farlowia 1: 95-118.

31/ Rowell, John B. 1951. Brown patch observations on bentgtass. Plant Dis. Rptr. 35: 240-242.

32/ Schardt, Al. 1925. Brown patch control resulting from early-morning work on greens. Bull. of the Green Sec. U.S.G.A. 5(11): 254-255.

33/ Sherwood, R.T. and C.G. Rindberg. 1962. Production of a phytotoxin by Rhizoctonia solani. Phytopath. 52: 586-587.

34/ Shurtleff, Malcolm C. 1953. Factors that influence Rhizoctonia to incite turf brown patch. (Abstr.) Phytopath. 43: 484.

35/ ————. 1955. Control of turf brown patch. Agt. Exp. Sta., Univ. of RI. Contrib. 862: Bull. 328. 25 pp.

36/ ———— 1953. Susceptibility of lawn grasses to brown patch. (Abstt.) Phytopath. 43: 110.

37/ Smith, Leon R. and Lee V. Ashworth, Jr. 1964. Effect of organic amendments and PCNB upon inoculum potential of Rhizoctonia solani in field soil. (Abstr.) Phytopath. 54: 626.

38/ Sprague, Rodetick. 1950. Diseases of cereals and grasses in North America. The Ronald Press Co., New York. 538 pp.

39/ Stuckey, I.H. 1942. Influence of soil temperature on the development of colonial bentgrass Pl. Physiol. 17: 116-122.

40/ Vaartaja, 0. 1964. Survival of fusarium, phythium, and Rhizoctonia in very dry soil. By-monthly Prog. Rept., Dept. Forestry (Ent. Path.) Can 20(6): 3.

Is Your Turfgrass Problem Due to Soils or Irrigation?

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A turfgrass manager knows a problem turfgrass area can be caused by one or a combination of factors. The underlying cause can often be traced to the soil or water because of improper preparation of the turf area or poor management practices, principally irrigation.

To find out whether the problem is caused by soil or water, it is helpful to understand some basic terms of the soil and plant sciences.

SOIL PROFILE: The layers in a vertical slice of soil. These layers are called horizons and differ from one another in color or texture. The thickness of the horizons and the way they are arranged are important to root growth and water penetration.

SOIL TEXTURE: Relates to the amount and size of the soil particles. Sand, silt and clay are size groupings of soil particles. Sands range from 2 to .05 millimeters (mm) in diameter; silt from .05 to .002 mm; and clays are less than .002 mm.

2mm	.05mm	.002mm	
Gravel	Sand	Silt	Clay

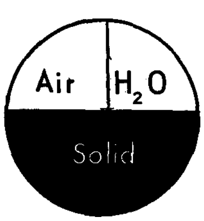
The relative size of the upper limits of sand, silt, and clay might be better visualized if they could be magnified 1,000 times. The 2-mm sand particle would be 6.5 feet in diameter; the .05-mm silt particle would be 2 inches in diameter; and the .022-mm clay particle would be .04 inches in diameter.

If the surface of these particles could be laid out flat, their relationship could be compared. The surface from one pound of sand would cover 1 acre; the silt, 10 acres; and the clay, 30 acres.

SOIL STRUCTURE: Sand, silt and clay seldom occur as separate units in the soil; rather they combine into larger groups of particles. Soil structure refers to the arrangement of the individual soil particles into small aggregates. In sand the individual soil particles are large, and so are the pore spaces between them.

Soils containing the fine silt and clay particles would not have large pore space for satisfactory movement of water and air if the particles existed as individuals. Fortunately, silt and clay particles tend to group together, forming larger clusters called aggregates. Between these aggregates the pore spaces are much larger than between individual particles.

A soil aggregate can be likened to a popcorn ball. The popcorn kernels are the individual soil particles, and the syrup holding them together is colloidal material in the soil derived from minerals and organic matter decomposition. A bowl full of popcorn balls will have larger air spaces than if they existed as individual kernels of popcorn.



NORMAL SOIL

SOIL POROSITY: This is the percent of the soil volume not occupied by soil. A "normal" soil may be considered to have one-half of its volume solid material and the remainder pore space. Under ideal conditions one-half of the pore space is air and the rest filled with water.

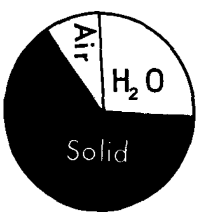
Water is held as a film around the soil particle. The force holding the water is known as tension or suction. As the soil dries out the water films become thinner and the suction increases, thereby making it more difficult for the plant to obtain water from the soil.

If silt and clay soils, with large surface areas, existed only as the individual particles, the pore spaces would be small and filled with water.

Roots grow in the pore spaces surrounding the soil particles only if there is a favorable soil-air-water relationship.

Larger pore spaces permit rapid movement of water and air into the soil. The larger pores may contain water during irrigation but gravity and capillary forces will pull some of the water out of these pores and air pushes in. Smaller spaces may hold some of the water with such force that gravity will not cause the water to drain out, but the plant roots can remove it from these pores and then it is replaced by air.

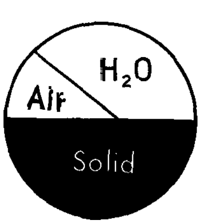
SOIL COMPACTION: This is the squeezing or compression of soil which results in a loss of pore space, primarily the larger pores. Soil compaction occurs when a weight or pressure is applied to a soil wet enough so that soil particles lose their binding action and slide past each other, these particles which move tend to fill the larger pore spaces.



COMPACTED SOIL

With compaction the water infiltration rate is reduced and runoff frequently occurs. Even a thin compacted zone 1/4- 1/2" thick can cause these detrimental effects. A common result is that only the top few inches of soil are wetted by an irrigation. If water cannot move readily through the soil it fills the few remaining large pores and air is excluded.

SOIL STRATIFICATION: Defined as layers of soil with different texture, structure, density or composition.Soil stratification may greatly impede water penetration.



SOIL WITH POOR DRAINAGE

Water supplied directly to a layer of coarse sand exposed at the surface will enter readily through the large pores of the sand. When a sand layer occurs within a clay or loam soil, water will not move into the sand layer until a thin layer of the soil above the sand layer becomes excessively wet; an excessively wet soil has almost all the pore space in the soil filled with water. When near saturation occurs water will move through the sand because saturated soil cannot hold all the water. A layer of organic matter will restrict water movement as a sand layer does.

A clay layer within a sandy or loam soil may actually restrict water movement more than the sand does, because water moves through the clay more slowly and may cause

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the soil above the clay layer to become saturated. However, the sand or loam soil above does not have to become saturated before water moves into the clay.

RESPIRATION: It is from this process that a plant derives energy for its growth and metabolic activities. In order for a plant to take up nutrients and sometimes water, work is required. Energy for this work is derived from respiration. In this process oxygen (0_2) is consumed and carbon dioxide (CO_2) is released. Carbon containing compounds of the plants sugars (CH_20) is the source of fuel.

$$(CH_20) + 02 \xrightarrow[\text{living organisms}]{\text{Respiration of}} CO_2 + H_2O + \text{Energy}$$

This information is helpful in emphasizing the importance of having a plentiful supply of oxygen in the soil. A study by Stolzy and Letey of the University of Calif. at Riverside revealed that low soil-oxygen conditions were found most detrimental to plant growth when air or soil temperatures were high.

More important than the amount of oxygen in the soil is the speed with which it diffuses to the plant roots. Oxygen movement through air is many times greater than through water and may be likened to a jet airliner streaking through the skies compared to a man swimming in the water.

Atmospheric air contains 21 percent oxygen. Carbon dioxide in the soil may be toxic to plant roots. It is through the larger pore spaces in the soils that there is an exchange of gasses from the soil environment and the atmosphere.

THATCH: The layer of undecomposed organic matter between the soil and green verdure of the grass blades. Such a layer restricts water and nutrients into the soil and prevents the exchange of gasses between the soil and atmosphere.

HYDROPHOBIC SOILS: Water repellent soils. Because a soil becomes more water repellent as it becomes drier, it is important that nonwettable soils should not be allowed to become dry before irrigation. Organic matters are also usually water repellent.

DIAGNOSING YOUR PROBLEM

With the information that has been given as a background, does your problem, related to soils, water and irrigation, fit one of the following?

SHALLOW ROOTS: Shallow roots make turf more difficult to manage. Irrigations must be more frequent and it is especially important there be an abundant supply of air besides the water. Sometimes turf will wilt on a hot day, even though recently irrigated, if there is a lack of air.

The principal reasons for shallow rooting are either the physical impedance to root elongation or a poor soil-air-water relationship in the soil. Roots will not grow where it is too dry; neither will they grow where it is too wet. Roots will not seek out water. Roots will only grow where there is a favorable soil-air-water environment.

We are not able to walk through walls, neither are roots able to grow through hard, dense, compacted soils. The use of physical soil amendments when preparing the soil will help substantially to make the soils more friable, especially the finer silt and clay soils.

Soil compaction which restricts water penetration into and infiltration through soils often results in shallow rooting. A regular program of mechanical aerification will be of significant value in providing better air and water movement in such soils. The new method of "vertical-mulching" or "deep aerification" may be useful for the renovation of old, weak, compacted turf areas.

The presence of a thatch layer often results in shallow rooting. The roots may grow in the thatch itself where they can obtain sufficient oxygen and water. A program of regular aerification and vertical mowing are the best means for reducing the detrimental effects of thatch. Since thatch is hydrophobic or water-repellent, the use of a wetting agent (sometimes called soil-penetrant, surfactant or spray adjuvant) is often desirable.

Soil stratification and/or poor drainage may result in shallow roots. As the pore spaces are filled with water and air is excluded, rooting depths are restricted. When possible, break up such layering of soils while preparing the soils for planting. If physical soil amendments are to be used, be certain they are thoroughly mixed with the soils. If such amended soils are not open to the surface, they will impede water movement in the soils, rather than aid it.

Tile drains should be installed where there is poor drainage or high water tables. Such drains should be below the water tables and maintained for free flow from them.

As water evaporates from the soil surface, it is as pure water and salts are left behind. Unless sufficient water passes through the soil to leach these salts below the root zone, a saline condition will exist, thereby restricting root and plant growth.

WATER RUNOFF: Water runs off the surface of a soil because it is being applied faster than the soil can accept it. This is common on slopped areas. Dense, fine-textured clay or silt soils, soil compaction, or a thatch layer can cause water to flow from the surface of a turf rather than readily enter the soil.

Slow application rate sprinklers are available. In areas where runoff is a problem such sprinklers should be used as much as it is practical to still receive the desired coverage and fit into the time allowable for irrigation.

Regular programs of mechanical aerification and vertical mowing will help increase the amount of water that will enter the soil rather than run off.

Possibly one of the best means for overcoming the problem of surface water waste is by applying the water in short, frequent intervals. With the increasing use of automatic timing systems water can be applied 5 minutes or so each hour, until enough has been applied to reach the desired depth.

DRY SPOTS: Such conditions arise either from compacted areas or poor water distribution from the sprinklers. If the problem is caused by soil compaction, a program of aerification will help.

If you suspect that the sprinklers are not satisfactorily distributing the water, a sprinkler can-test can be of great benefit. The test will define the extent of poor water application so that methods for correction can be started. This may mean cleaning or adjusting the sprinkler heads,

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obtaining new heads or nozzle sizes, or installing spur lines and additional sprinklers.

HARD SOIL: Compaction soils are usually hard. Certain clays tend to have a cementing action as they become dry. Excessive irrigation is not the answer to correcting hard soils.

The use of physical soil amendments when preparing the soil to be planted will greatly assist in obtaining better soil structure and porosity. This means less chance of the soil becoming hard. The use of a top dressing (redwood sawdust or other such organic matter at about 25 percent by volume) following aerification aids in reducing the hardness of the soil.

WEAK TURF: Turfgrasses of little vigor usually will be of poor color and cannot tolerate much traffic. Conditions such as poor drainage, soil stratification, compaction or incorrect irrigation practices can result in a poor soil-air-water environment within the root zone. When this occurs, the plant may not be able to take in nutrients or water, even if sufficient supplies are available.

Another condition which leaves the plant stunted or weak is excessive salinity. If good drainage and conditions for satisfactory water movement through the soil are provided, added amounts of water can be applied periodically to leach the salts below the roots.

WATER STANDING ON THE SURFACE: This condition restricts the exchange of gasses between the atmosphere and soil creating unfavorable soil-air-water relationships.

Any condition which impedes the entry of water into a soil and the flow through it can cause water to remain standing on the surface. Determination of the conditions which may be causing poor water movement is necessary before the corrections for these problems can be effectively used.

SOUR-SMELLING SOIL: Many turfgrass superintendents probing their soils, especially at the deeper-depths, have found foul odors associated with it. Most often this is from excess water remaining in the soil without air. Any condition which halts or seriously slows the movement of water through the soil can cause this problem. Excessive irrigation is also a widespread cause of such a problem.

Unless better irrigation management is practiced, good drainage cannot correct the condition. Since roots and surface evaporation, are the main forces which remove water from the soil, it is only necessary to water to a depth where the majority of the roots are located and only as often as needed. When the lower soil reservoir containing fewer roots dries out somewhat, then additional water can be added to reach this area. As a more favorable soil-air-water environment is created, odors will leave and usually roots will begin growing to deeper depths.

CONCLUSION

It is more profitable to prevent soil and water problems by careful preparation of the soil before planting than to correct the problems when created. The use of physical soil amendments can be of value. Correct sprinkler design and installation will yield rich dividends. An irrigation system should be selected by needs rather than price. Maintenance costs and added problems may soon greatly exceed the savings from a poor selection. With the new automatic controllers there usually is no longer any excuse for the wasteful surface runoff of water.

Regular programs of aerification and vertical mowing to fit the needs of your turf can often reduce the soil and water problems. Sprinkler can-tests have proven their value many times. Soil penetrants may be effective if a condition where they are needed exists. Soil-moisture sensing devices such as the tensiometer have been used successfully as a guide for determining the frequency and amounts of water to apply.

Good irrigation management is difficult to teach. Unfortunately it is not easy to have set schedules on how often to water and for how long. How the turfgrasses are watered can affect all other practices, including fertilization, mowing, and insect, disease and weed control.

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