the placed sod must be syringed several times so that it does not wilt. We found it worked out better in sodding if we cut only that amount that we could handle daily. If bad weather was forecast we "played it close to our vest," and cut only enough sod that could be laid from hour to hour.

4. Early maintenance of newly sodded green.

As soon as the sodding job is completed, the green should be rolled several times with a large diameter hand roller prior to use of a heavy roller. The latter has a tendency to push or slide rather than level the sod. After the green has been rolled 4 or 5 times with the heavier roller, it is ready to be topdressed. Then it is ready for mowing. Care in mowing the first few weeks is essential to keep from scalping. Care should also be taken to mow frequently so as not to allow the turf to "grow rank."

4. A view of No. 14 green ten days after the resodding operation.

TOTAL COSTS FOR RESODDING 6 GREENS

Nursery—labor		
To establish rows of stolons	$ 130.00	
To stolonize 37,000 sq. ft.	1,100.00	
To mow	460.00	
To spray—fungicide program	80.00	
To fertilize	50.00	
To irrigate	100.00	
To topdress	190.00	
Total		$2,110.00
Nursery—materials		
Fertilizer	$ 350.00	
Fungicide	120.00	
Topsoil	550.00	
		$1,020.00
Labor required to condition soil on greens and to transplant sod at $2.00 per hour		$2,580.00
Totals		$5,710.00

Rhizoctonia Solani in Relation to Maintenance of Golf Courses

By R. J. LUKENS and E. M. STODDARD
Department of Plant Pathology, Connecticut Agricultural Experiment Station, New Haven, Connecticut

Rhizoctonia solani (Kuhn) is a difficult fungus to deal with in golf courses. Brown patch is the most common symptom of its presence. Because of the headaches it causes the golf course superintendent, we will discuss the habits of the fungus as they apply to the development of better ways to cope with it.

This fungus causes damping off and root diseases of many plant species. Although its name has been changed several times during the past 230 years, it has been known as **Rhizoctonia solani** (Kuhn) for the past 100 years. The vegetative form is pathogenic to grass in golf greens and elsewhere. The fruiting form of this fungus is found rarely and goes by the name of **Corticium** or **Pellicularia filamentosa.**

Rhizoctonia solani causes brown patch disease when the fungus kills leaves and crowns of bentgrass under warm, humid conditions. Piper and Coe (7) first described this disease when they saw it on golf greens in Philadelphia. They noted the typical smoke ring symptom, and discovered sclerotia (black compact masses of old fungal hyphae) formed on old diseased plants. These sclerotia started new fungal growth when the weather was warm and moist. The new growth from the sclerotia started another round of brown patch. The disease appeared to be most severe on wet greens suffering from poor soil drainage. These observations were later confirmed and extended by Monteith (5) and Dickinson (2).

Piper and Coe (7) suggested that brown patch began from sclerotia, from which they produced brown patch artificially. They showed that the artificially produced disease had the same temperature and moisture requirements as the disease in the field. With such convincing evidence pointing to sclerotia as the source of disease, the question of other sources was neglected.

Are there other possible sources of

disease? Let us look at what occurs in the field. Turf on putting greens is and has been sprayed faithfully throughout the summer for many years. One would surmise then that sclerotia of **Rhizoctonia solani** persisting in the sod would be killed or exhausted from continual use of fungicides and that brown patch would tend to be less of a problem when the weather becomes hot and humid. Yet, when a spray application is missed at a crucial time, the disease breaks out with its normal aggressiveness. This suggests other sources of disease, possibly from outside the treated area and possibly from beneath it.

Rhizoctonia solani, which is present in most soils, can live on dead organic matter or attack many kinds of plants for its food. Topdressing for greens made by mixing topsoil with sand and organic compost is an ideal food for **Rhizoctonia solani.** The fungus can build itself up in this mixture and is ready to go when the topdressing is spread on the turf. What are we doing? The villain is fattened in the topdressing, evenly spread over its victim, and then gently watered into the turf awaiting for the moment of attack. No fungus ever "had it so good!"

We conclude that topdressing is an important source of brown patch. **Rhizoctonia solani** has been found in topdressing from two golf courses this past season, and brown patch was severe where infested topdressing had been applied.

What control measures may be used to rid topdressing of **Rhizoctonia solani?** These include steaming, or else adding fungicide to topdressing either when mixing or watering it into turf. Inoculating topdressing with other fungi that destroy **Rhizoctonia solani** may help to control the pathogen.

Another external source of **Rhizoctonia solani** is infested seed. Leach and Pierpoint (4) found the fungus could be carried by bentgrass seed. **Rhizoctonia solani** on the seed may cause damping off of seedlings as they break through the ground. This kind of damping off can be controlled by seed treatment, or by watering the seeded area with an effective fungicide.

In the 40 years since Piper and Coe (7) reported on brown patch, Rhizoctonial infections on roots of putting green turf has received little attention. Bloom and Couch (1) have recently referred to Rhizoctonial crown and root rot as the last stages of brown patch development. Work at the Connecticut Agricultural Experiment Station has shown that root infection of **Rhizoctonia solani** on grasses is a cause for brown patches in lawns (6). We have seen severe root infections of the fungus in specimen from various golf greens in Connecticut. Roots penetrate less than two inches in soil when they are severely infected with **Rhizoctonia solani.** In some cases there is no evidence of top infection. The fungus attacks roots in cool as well as warm weather. But if the weather becomes warm and humid, diseased roots can be an important source for causing top infection or brown patch disease besides causing extensive root injury.

In addition to serving as a possible source for brown patch disease, diseased roots may also cause wilt. Wilting results from blocking the water supply to leaves caused by either vascular or root diseases. Turf on putting greens suffering from wilt has shallow roots severely infected by **Rhizoctonia solani.** In cases where the fungus is controlled on roots of turf on putting greens, symptoms of wilt disappear and root growth is improved.

Turf with diseased roots has less vigor and requires more care than heathy turf. Frequent water and fertilizer applications, coupled with syringing greens daily to combat wilt, make conditions favorable not only for brown patch, but also for Curvularial blight. This makes necessary the multiple sprays now needed for disease control. Our preliminary studies indicate that turf on putting greens with a healthy root system 6-12 inches deep is less susceptible to top infecting diseases and require fewer of the usual items of care.

Control of Rhizoctonia solani

Current control measures depend largely upon foliar sprays. Improvements in the available sprays and spraying equipment made foliar sprays the principal control measure for brown patch. Harrington (3) discovered that thiram was effective against brown patch on putting green turf, thus opening the door for many organic fungicides to be tested for control of turf diseases.

Rhizoctonia solani is known to cause a complex of diseases in turf on putting greens. The best control of the fungus is not achieved through any single operation such as foliar sprays, but through the use of many methods of disease control in the various operations performed on a green. Some of these other methods are the use of disease resistant bentgrass varieties, the use of disease-free seed or stolons, and the use of clean topdressing. Another method is to attack **Rhizoctonia solani** where it lives—in the soil. This we have done with soil drenches.

Root infections of **Rhizoctonia solani** on turf can be controlled with soil drenches of oxyquinoline sulfate. The treatment is one ounce of the compound in 16 gallons of water applied at the rate of one pint per square foot on turf. A single treatment with this solution may control brown patch for three years. The long effective period of the chemical drench was seen on several lawns during the past 10 years. Oxyquinoline sulfate does not control brown patch when used as a foliar spray.

Soil fungicides can control Rhizoctonial infections on turf roots on golf greens used for normal play. In August 1959, greens suffering from Rhizoctonial root infection, wilt, Curvularial blight, and chemical injury from futile fungicide applications were injected with nabam (1:600 dilution of 22% commercial sodium ethylene-bis-dithiocarbamate). Nabam is a water soluble fungicide known to control **Rhizoctonia solani** on other crops. We treated the turf with a tree feeding injector, pumping the fungicide into soil at 200 pounds per square inch. The injector was inserted every 4 to 5 feet, 8 to 12 inches deep, and held open 5 to 7 seconds depending upon the resistance of the sod and distribution of fungicide in the soil.

The turf immediately responded to the treatment. In a week, new growing points of turf were evident and in a month all areas of greens had recovered except where turf was actually killed. Together with topdressing and reseeding bare areas, the greens fully recovered in two months. At time of treatment, roots were two inches in depth and severely infected with **Rhizoctonia solani.** In two months, new roots penetrated to 12 inches and remained healthy. The effectiveness of the injection persisted throughout the season of 1960.

In June 1960, we set up experiments on four greens that had been treated with nabam in 1959. The test greens were divided into four strips. One strip was left untreated. We injected one strip with water, one strip with nabam (1:600 dilution) and the last strip with oxyquinoline sulfate (1:2000 dilution). The greens were fertilized in the normal manner and watered four hours at night when required. The persistence of the 1959 treatment masked the differences in the 1960 tests except that grass in nabam injection strips had more roots than other treatments. In August 1960, both nabam and oxyquinoline sulfate treated strips had one-half the incidence of **Rhizoctonia solani** than that occurred in the strips receiving water or in the control strips, although all treatments had good root systems. By October, roots in the control strips were shorter, while nabam treated roots grew an inch longer (compare B and C in illustration).

The increase in root activity of nabam treated turf may be caused in part by root stimulating properties of nabam or breakdown products from nabam. In other experiments, we found that drenching rooting material with nabam stimulates rooting of geranium cuttings set in the material afterwards.

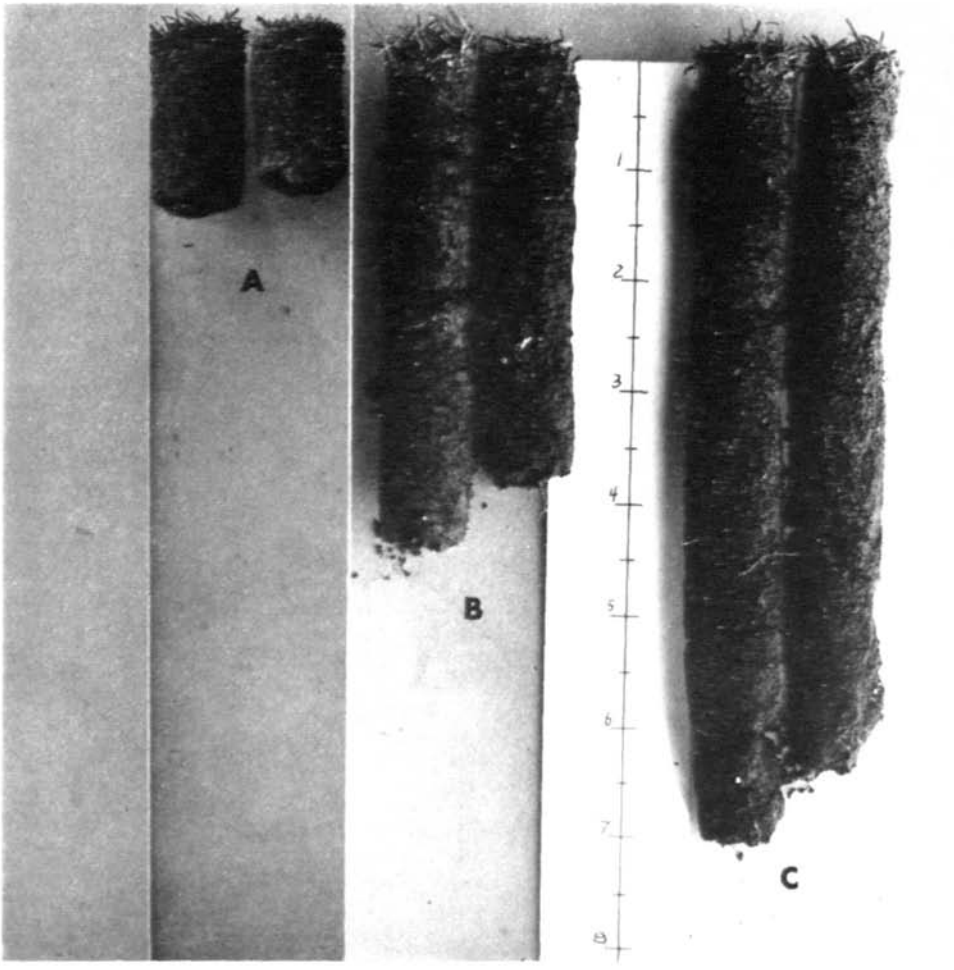
An unexpected benefit accompanied the injection treatment. Golfers noticed their approach shots stuck to the surface of greens and rolled true. Apparently, injecting water under pressure breaks up a compaction layer several inches below the surface of the green and seems to improve the playing surface. This may also partly explain the quickness of roots to penetrate after the injection.

The superintendent of the golf course cared for the other greens in the following manner during 1960: nabam was injected into the sod in early June. In August, the greens were aerified and topdressed. The topdressing was watered into turf with nabam (1:800 dilution). Two sprays of thiram were applied during the summer as a precaution although no evidence of disease appeared on greens. Watering was done at night for four hours when required. Other golf

courses in Connecticut were damaged by wilt and Curvularial blight. Brown patch did not occur to any extent in Connecticut this season.

A golf course situated on a hilltop was suffering from wilt. We found that the roots were one and one-half inches deep and severely infected with **Rhizoctonia solani.** Two months after injecting greens with nabam, symptoms of wilt were reduced. The treated sod developed an active root system down to four inches with some roots penetrating deeper. At another course, not treated, turf suffering from wilt still had roots penetrating only one and one-half inch and severely infected with **Rhizoctonia solani.**

These tests with soil injections or drenches of fungicides are preliminary in nature. Evidently such treatments control root infection of Rhizoctonia but more experience with them is needed to see whether they can control top infecting diseases. These experiments are an



ROOT DEPTH OF TURF ON PUTTING GREENS: "A", AUGUST 1959, BEFORE TREATMENT; "B", OCTOBER 1960, ONE INJECTION OF NABAM (AUGUST 1959); AND "C", OCTOBER 1960, TWO INJECTIONS OF NABAM (AUGUST 1959 AND JUNE 1960). THE RULE IS IN INCHES.

effort to find better ways to control turf infections of **Rhizoctonia solani** than the laborious foliar sprays now being used.

What have we learned? **Rhizoctonia solani** attacks roots as well as leaves and crowns of turf on putting greens. Besides sclerotia found in old diseased grass, other probable sources of inoculum are infested soil, topdressing, and seeds. Many practices now used in maintaining golf greens have failed to improve root systems or to control root infections. In fact they may actually favor other diseases. Injecting solution of nabam into turf reduces Rhizoctonial root infections, improves root systems, and possibly reduces incidence of top-attacking diseases. With a greater appreciation of the problem of **Rhizoctonia solani**, diseases caused by the fungus may be coped with more successfully.

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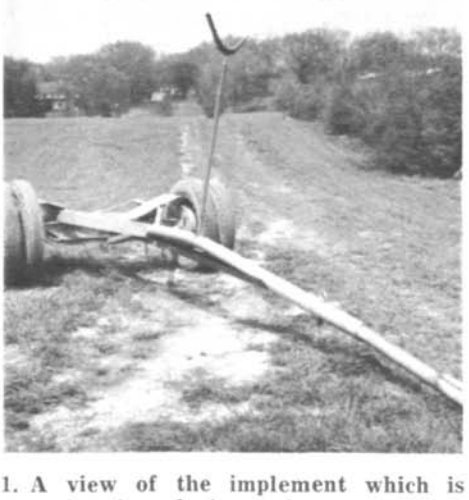
An Improved Method of Transplanting Large Trees

By A. M. RADKO
Eastern Director, USGA Green Section

The series of pictures below were taken last fall of a tree transplanting method used by Mr. Jimmy DeBottis, superintendent of the Country Club of Rochester, Rochester, New York. The prime mover in the use of this technique is an implement improvised by Mr. DeBottis to take the place of the "stone boat" most commonly used in moving large trees over turf or soil. Trees 30 to 50 feet high can be moved rather quickly and easily using this implement and this technique is compared to that of the "stone boat." Other advantages are readily obvious.



1. A view of the implement which is made of angle iron, pipe, and a dual wheel axle.

2. The rough digging is done by a front end loader or backhoe. A minimum of fine work with pick and shovel is required. The tree is selected from the wooded area on the course.