

There is a cumulative effect from mercury compounds in the soil. The first treatments of the year are not likely to be as effective as the later treatments. When the turf has been treated year after year less mercury is required to check the disease than on turf where no treatments have ever been applied. This cumulative effect applies also to the chance of injury to turf due to chemical burn. Where much mercury has been used the grass is burned by smaller amounts than where no mercury has been used previously. The first treatments therefore can safely be much stronger than the subsequent treatments particularly if the turf is treated at regular intervals. New turf can stand stronger treatments than older turf which has been regularly treated.

APPLYING FUNGICIDES

Several methods for applying fungicides to turf are available for golf courses. The method that is used varies with the preference of the greenkeeper and the available equipment. A method may be practicable on one course and impracticable on another course because the equipment and trained help vary considerably on different courses. The method used will also depend on the frequency with which the disease occurs and the amount of turf that must be treated, since it is important to apply fungicides promptly after an attack of fungi is noticed, so that the disease may be checked quickly and the severity of the injury lessened. The method to use is that which will give the most even distribution in the shortest time and at the least cost.

The fungicides usually used on golf courses are mercury compounds which, if carelessly applied, cause injuries to turf that may be more serious than the diseases for which they are applied. The small amounts of the fungicides necessary to cover large areas make it difficult to distribute them evenly. It is usually desirable to dilute them to give greater bulk, for only rarely is it possible to apply a fungicide to golf course turf without dilution. Any of the chemicals effective in the control of turf diseases may be applied either in water or mixed with sand, soil, or other material.

It is essential to obtain even distribution regardless of whether the fungicide is applied in water or in a dry state. Uneven distribution may result in chemical burns on those areas which obtain an excess of the material and ineffectiveness of the treatment on those areas which do not receive an adequate amount of the fungicide. To assure even distribution of the material to be applied it is advisable to make the application in two parts. The first part is applied by starting at one side of the putting green and walking back and forth in parallel lines far enough apart so that the application does not overlap or that no part of the turf is missed. Great care should be taken that the treatments do not overlap since bad burns may result where overlapping occurs. After the first half of the material has been applied the second half is applied by walking back and forth in parallel lines which are at right angles to the direction of the first treatment. Treatment thus made in two directions greatly increases the uniformity of the distribution. This method is often used in seeding to assure even stands of plants, and it is useful whether the treatment is made dry in sand, soil, compost, or dry fertilizer or in liquid from sprayers, sprinklers, or proportioning machines.

The turf should be watered thoroughly immediately after the

application of a fungicide, except where it is desired to leave the fungicide on the blades of grass, as is the case when very small amounts of corrosive sublimate are applied. The laborers must be trained to water correctly. If the greenkeeper is not watchful, the laborer will wash the fungicide from the elevations to the low areas of the putting green by careless watering. In consequence, the elevations will be subject to reinfestation by disease while the low areas will be liable to suffer from burns due to the concentration of the fungicide. The men should be allowed to water only with nozzles that create a fine spray or mist, and should be instructed to hold the nozzles up so the spray may lose its force before striking the turf.

When excessive amounts of fungicide have been applied to turf either by high rates of application, heavy doses from uneven distribution, or by spilling of concentrated solution or dry materials, the grass should be watered immediately and abundantly. In cases when the fungicidal material has been spilled or applied heavily on small areas the watering should be concentrated on the affected areas so that the chemical will be washed into the soil.

After an application of fungicides is made, whether it is by the dry method or liquid method, it should be watched for burning. When the turf appears to be burned from an application of fungicide it should be watered again immediately. If the watering is liberal much of the injury from burning will be eliminated. Fungicidal treatments should not be applied to turf and then be forgotten.

One often finds that laborers are apt to give double doses of fungicides to diseased areas unless warned. This may occur either with spray or dry methods of application. It is not uncommon to see a spray operator pause to spray more thoroughly a diseased area, or a man spreading by hand throw a few extra handfuls on the diseased areas. This concentration on the diseased turf usually results in bad burns and perhaps kills much turf that ordinarily would have recovered. The men applying fungicides should be told that the treatment, when made over large areas, is to prevent spread of the disease to healthy turf and that therefore the fungicide must be applied evenly, regardless of diseased or healthy parts.

In handling any of the mercury fungicides care should be taken that the chemicals are not scattered about so that there is any danger that they will become mixed with food of animals or human beings because they are extremely poisonous. If any of the mercury compounds are accidentally swallowed, a physician should be called immediately. Vomiting should be forced by giving soapsuds or salt in warm water, followed with white of egg or milk of magnesia. There is a possibility that when even small amounts of mercury are absorbed into the body at different times, an accumulation of the metal occurs in the system, which may be injurious at some later time. To guard against this danger it is advisable to wear a wet cloth or other filtering mask over the nose and mouth when preparing mixtures of these compounds and when applying them to the turf.

Some mercury compounds have a corrosive action on metals. All metal equipment should be washed thoroughly after having come in contact with these chemicals. Corrosive chemicals should always be kept in wooden, glass, or earthenware containers and should not be handled with metal spoons or paddles. They should not be weighed on metal pans of scales unless the metal is protected by paper or other non-corroding materials. Dry mixtures of these fungicides should

be kept in wooden containers, when stored even for short periods. Sprayers and other equipment used for mixing and applying liquid treatments should be washed after use to prevent corrosion. Hose connections should be examined from time to time to determine whether or not they have been weakened by corrosion. Severe burns have resulted on greens where hose connections have broken and large quantities of fungicides have spilled on the turf.

Dry Methods of Application

Many greenkeepers prefer to apply fungicides in the dry state. This method has an advantage over the spray method in that it does not require a large outlay for expensive equipment, nor is there heavy equipment to haul over the golf course. Some greenkeepers find that they can treat their putting greens more quickly by the dry method than by the liquid method.

Fungicides have been applied in the dry state by dusting them on the turf. This method was used when Bordeaux mixture was applied to turf to control brownpatch. Since treatment with Bordeaux mixture has been discontinued the practice of dusting has fallen into disuse on golf courses. With the mercury fungicides it has been found that the dust method is unreliable; too much of the chemical is lost on windy days; the small amounts needed for turf make it difficult to apply evenly without diluting it with some inert material. The poisonous character of the mercury fungicides makes it unsafe to breathe any of the chemical, which can scarcely be avoided if the material is distributed as a dust.

When chemicals are applied in the dry state they should, to obtain best results, be mixed with comparatively-dry, finely-screened topsoil, compost, sand or other material that will increase their bulk and render even distribution more likely. In mixing the chemical with dry materials it is necessary to obtain a uniform mixture and to pulverize all the lumps of the chemical, for if lumps of a concentrated chemical are permitted to lie on turf they are likely to cause severe local burns. An excellent method of mixing a chemical with soil is to first mix it with a small quantity of dry, sharp sand; preferably about twice as much sand as chemical should be used. These are then rolled together with a rolling pin, a piece of pipe, or a bottle. In rolling them together the lumps are broken by the grinding action of the sand. The rolling and mixing should be continued until a uniform mixture is obtained as indicated by the absence of streaks. The chemical and sand can also be forced through a very fine screen, but this will not result in as fine a mixture as rolling. The material to be applied to the turf is spread out on a tight floor or smooth concrete so that it is in a layer not more than 2 or 3 inches deep. The chemical and sand mixture is then scattered over it, raked in thoroughly, and shoveled over several times so that it is uniformly mixed. A revolving barrel churn, a small revolving concrete mixer, or even a home-made mixer, may also be used for mixing the chemical and sand with the bulky material.

Storage of mixtures of mercury fungicides and soil, compost, or fertilizers for short periods does not destroy the effectiveness of the fungicides. It does, however, lessen the danger from burning, even when allowed to stand overnight after mixing. If such a mixture is allowed to stand from one season to the next it loses some of its effectiveness. Some, however, is retained so that when one has a



Figure 21.—On many golf courses fungicides are distributed dry, mixed with sand, compost, or similar material. To insure even distribution with this method all lumps of chemicals should first be broken. An effective method for accomplishing this is by rolling and mixing them in fine sand (above). This is best done on a piece of heavy paper or canvas, which can be lifted at the corners to throw the rolled material back into a pile and expose new lumps to the rolling operation. The rolling and piling are repeated until no lumps remain in the mixture. A pile of screened soil is then spread out and the mixture of sand and fungicide is spread evenly over the pile and worked in with a rake (below). The pile is then turned over several times to make a thorough mixture.

supply already mixed it may be used, but to be effective it must be used at higher rates. It is advantageous to mix enough material to meet the demands for treatments for about a month in advance so that when disease occurs it can be promptly treated.

When the dry materials are to be broadcast over the turf, an 8-quart bucketful applied to 1,000 square feet is a fair amount to use, but the quantity depends on the preference and skill of the man who applies it. Some men can broadcast a small amount uniformly; others prefer a larger amount. The amount of fungicide should be weighed and mixed with a definite quantity of material so that each bucketful contains the amount of chemical that is to be applied to a definite area. A large amount of material can be mixed at one time so that applications can be made whenever they are needed and the mixture can be broadcast over a green at the rate of a bucketful to 1,000 square feet, or at any other rate that is preferred to obtain even distribution.

Fungicides are often mixed with fertilizers to give them greater bulk. Such fertilizers as cottonseed meal, activated sludge, poultry manure, and other organic or dry fertilizers are suitable for such use. The fertilizer does not reduce the effectiveness of the fungicide nor does the fungicide affect the fertilizer. The fertilizer and fungicide can be given additional bulk by mixing with sand, topsoil, or compost so that a bucketful contains the amount of fungicide and fertilizer that is to be applied to 1,000 square feet. In some cases the fertilizer is bulky enough so that addition of other material is unnecessary. The amount of chemical then added to the fertilizer should be such that the amount of fertilizer it is desired to apply to a green contains the quantity of fungicide required for that area.

Dry materials are usually broadcast from buckets by hand. It is customary to apply two thin applications in opposite directions, as in seeding. This helps to prevent uneven distribution, which might cause injury by concentration, or continuance of disease in small areas which have been missed. Sometimes the application is made with a topdressing machine or a fertilizer distributor. When the dry method is used masses of the material on the turf give evidence of any careless or uneven distribution. The turf may be dragged with a steel mat or some similar equipment, or poled with bamboo poles in order to increase the evenness of distribution. However, the drag used should be light-weight since any bruising of the grass may result in burning.

Mercury fungicides may also be applied when mixed with topdressing materials. By this method the fungicide is applied at the time of topdressing the putting green. However, the labor involved in mixing the fungicide with the topdressing material is usually more than is saved by the necessity of making only one application. It is also very difficult to mix the small amount of chemical directly with the large amount of compost that is needed to topdress a green. It is best to first mix it with a small amount of sand as has been suggested above and then mix it thoroughly through the topdressing material. Uneven distribution often results from the application of fungicides in topdressing because of the difficulty of obtaining a uniform mixture. It is not recommended in most cases. In many instances fungicides must be applied more often than the turf needs topdressing and other methods must then be used.

Liquid Methods of Application

The mercury fungicides are of two types; those which are soluble at rates used on golf courses, and those which are insoluble. Soluble chemicals are those that disappear after being placed in water for a time. Examples of soluble chemicals are corrosive sublimate, sulphate of ammonia, and common table salt. When these chemicals go into solution they diffuse to every part of the liquid so that each unit volume of the liquid contains an equal amount of the chemical. To evenly distribute such chemicals to turf it is only necessary to make a uniform application of the liquid on all parts of the turf.

Although corrosive sublimate is soluble in amounts used on golf courses, the process of dissolving it in cold water is often slow. Some chemicals dissolve much more rapidly in water in the presence of another salt in solution. Corrosive sublimate dissolves rapidly in water if there is added with it $\frac{1}{4}$ its weight of common salt or ammonium chloride. Four pounds of corrosive sublimate quickly dissolves in a gallon of water to which 1 pound of salt has been added, but without the salt it will not dissolve in that quantity of water. This amount will treat approximately 22,000 square feet of turf, or four moderately-sized greens. During the hot summer weather this amount used at reduced rates will treat eight putting greens. The solution may be prepared in glass jugs, earthenware jars, or wooden kegs. Corrosive sublimate solutions should never be placed in metal containers because of their corrosive action on metals. Not only is the container corroded but the solution is weakened and it is impossible to determine the quantity of such a weakened solution that is needed to get the desired control of disease. As corrosive sublimate damages metal parts, the equipment should be washed thoroughly after being used.

Insoluble chemicals are those which do not disappear when placed in water. Examples of these are calomel, arsenate of lead, and lime. When these chemicals are placed in water they settle to the bottom of the container so that the liquid above contains practically none of the chemical. In order to make uniform applications, these chemicals must be finely ground and must be kept constantly stirred so that the chemical will be suspended in the liquid in much the same way that fine clay particles are suspended in muddy water. Some chemicals remain suspended in the liquid for longer periods than other chemicals. The insoluble mercury compounds, such as calomel, are very heavy and settle quickly unless vigorously agitated. When calomel is to be applied to turf, therefore, it is not only necessary to apply the suspension evenly but constant agitation must be provided so that each unit volume of the suspension contains an equal amount of the chemical. Neither salt nor ammonium chloride will aid in dissolving calomel.

It is often easy to become careless with the liquid treatments and to slop or spill quantities of the material on turf. Such carelessness is not immediately detected when the material is in solution for there is no excess apparent on the surface as is the case when dry materials are spilled. Carelessness of this kind, however, in a few days often results in areas of dead turf that take a long time to heal.

Many golf clubs have power sprayers which they use for applying fungicides and fertilizers to turf and for spraying trees and

shrubby on the course. The cost of such equipment is considered prohibitive on some courses. Some greenkeepers feel that they can treat their putting greens in less time with spraying equipment than with other methods and reduce the cost of treatments. When applications of fungicides or insecticides are made to coat the leaves with poison as is the case with many plant insect pests and diseases, spraying equipment is most effective. This is also true when small amounts of corrosive sublimate are applied at frequent intervals to check disease.



Figure 22.—Fungicides when thoroughly mixed in water can be readily distributed over a putting green in the form of a fine mist by means of a power sprayer and suitable nozzles. Success with this method depends chiefly upon the method of using the equipment.

With the power sprayers in use today it is not necessary to resort to the high dilution generally employed with sprinkling devices. A solution of from 5 to 10 gallons for 1,000 square feet is adequate to distribute chemicals evenly on putting greens, and some careful greenkeepers can use even less. The advantage of high-powered spray equipment becomes evident only when the spraying operation is conducted in a systematic way. For example, concentrated solutions or suspensions of the fungicide to be applied should be taken out on the course with the spray wagon so that it is not necessary to wait for the chemical to dissolve in the tank. The quantity of chemical in the solution should be known so that a definite amount can be measured into each tankful of water. The area of each green should be determined and the quantity of the solution or suspension to be used should be calculated so that all guessing will be eliminated. Many spray wagons have two compartments, and it is usually possible to fill one tank from a water outlet near the putting green while the green is being sprayed from the other tank. Two hose lines and nozzles are generally used in spraying the green. In any case the operator or operators should be trained to walk back and forth over the putting

green at a uniform pace in order that each portion of the green may receive the same amount of spray. With two operators the custom usually is to start at opposite sides of the green, and walk over it, back and forth, each on parallel lines, getting closer on each trip across the green until they meet at the center. After some experience the operators learn how fast they must walk in order to cover the area of the green 2 or 3 times with the quantity of liquid in the tank. The more often the operators can go back and forth over the green the more likely it is that the solution will be uniformly applied. Since bad burns may result from leaks it is quite important to have all connections in the tank and hose absolutely tight.

On certain small courses, particularly in the Northern States, where the turf diseases do not occur frequently, it is possible to apply fungicides to the affected areas with a sprinkling can. The chemical first should be dissolved or mixed with water in a wooden barrel in such a quantity that 50 gallons of the mixture will treat 1,000 square feet. For instance, if a treatment of 3 ounces of calomel to 1,000 square feet is desired, that amount of the chemical should be placed in 50 gallons of water. In that case, 1 gallon of the mixture will treat 20 square feet, which is an area 4 feet wide and 5 feet long. The tendency is to apply too large amounts of chemicals by this method and thus cause burns. It is well to treat an area of 20 square feet with a gallon of the liquid wherever the disease is present. It is important that the gallon in the sprinkling can be distributed uniformly over the area. Each time before a canful is removed from the barrel the mixture should be vigorously agitated so that the chemical will be in suspension. When applying the fungicide with a sprinkling can great care should be taken not to spill the liquid on the green as serious burns may result. The amount to be applied should be sprinkled on the turf in two applications which are sprinkled in two directions. However, applying fungicides by the sprinkling-can method is slow and where any large areas of turf must be treated this method is too expensive, and other methods should be used.

Barrel-sprinklers are often used on golf courses to apply fungicides. These use a dilution of 50 or 100 gallons of water to 1,000 square feet. It is necessary to stir constantly to keep insoluble materials in suspension, and it is also necessary to keep the distributing bar horizontal when moving over slopes to prevent one side from getting all of the treatment while the other side gets none. The operator should move quickly over the green so that he can cover it twice in two directions with the allotted amount of liquid for the area. Care must also be taken that he does not overlap the treatments since that would result in burns due to doubling the rate of application.

Proportioning machines of various types have been used for applying fungicides on golf courses. These can only be used with the soluble fungicides. The principle involved in proportioning machines is that a concentrated solution is drawn out of a container through a siphoning arrangement by the water from an ordinary watering outlet. Mechanical imperfections and varying water pressures at the outlet make it impractical to make uniform application with such apparatus and they are not widely used on golf courses.