of very little significance in evaluating the over-all fitness and productiveness of the soil. Evidence was found that the variable amounts of roots found in the soil cores was a major factor in the inconsistencies found in the bulk density measurements.

The heavy rates of water applied during the last 40 days of the experiment did not appear to limit growth. Clippings weights before and after the moisture treatment exhibited the same general trend of growth. This seemingly indifferent response was not anticipated; however, subsurface drainage appeared to be quite adequate so that no harmful effects resulted.

Because of the wide variations in the physical and chemical properties of soils presently used on golf greens, it would be foolish to suggest that these findings should apply to all situations. Every possible effort should be put forth to have the selected soils analyzed for their various physical and chemical properties before any green construction is attempted. Much additional work with other soils and skeletal agents, with other climatic environments, and with other grasses, is needed so that a more abundant and diversified library of information may be made available.

References

(1) Baver, L. D. Soil Physics. Third Edition. John Wiley and Sons, Inc., New York. 1956.

(2) Lunt, O. R. Minimizing Compaction in Putting Greens, United States Golf Association Journal and Turf Management. 9:5, 25-30, 1956.

SNOWMOLD CONTROL

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SNOWMOLD probably causes more damage to golf course turfgrass than any other disease in the snow belt—northern United States and Canada. The disease is most serious on the green proper, the aprons, approaches and shoulders. Bentgrass tees and fairways are likewise attacked, but in general, damage is less severe than on greens. Under extreme environment—heavy and persistent snow packs with temperatures around freezing—snowmold may cause damage on tees and fairways.

Two organisms—*Typhula itoana,* the "gray snowmold," and *Fusarium nivale,* the "pink snowmold," are responsible for this disease. These organisms are active between 28° and 42° Fahrenheit, when excessive moisture is present. This environment exists as the snow pack melts in late winter and early spring. The common name, "snowmold," has developed because of this association with melting snow. It should be pointed out, however, that the disease will develop whenever temperature and moisture are favorable, irrespective of snow coverage.

Several fungicides have been reported and are known to be effective against the snowmold organisms. The list includes Calo-Clor*, Phenyl Mercury, (Liquaphene, PMAS, etc.), Teresan, Semesan, Cadminate, and straight corrosive sublimate. This latter material has proven especially effective against the virulent strain of snowmold found in the Prairie Provinces of Canada.

The major problem associated with control of the disease is one of longevity and persistence of the applied chemical. This develops from the *necessity of applying the fungicide in late fall or early winter, after the soil is frozen and prior to the first snowfall which will remain.* Another problem is that of holding the fungicide in place when thaws occur in late winter or early spring. Often snow may melt, partially or completely, thus washing out or dissipating the material.

In an effort to find a material which would prolong the effectiveness and persistence of the fungicide, a snowmold test was located on an experimental green at the Toro Research and Development Center in the fall of 1953. This study was con-

** Trade names of chemicals and carriers included in the study are used for purposes of clarity and convenience.*

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tinued in 1954, 1955 and 1956. The results of the 1953 and 1954 tests (readings made in the spring of 1954 and 1955) were reported in the May, 1956, issues of "Golf Course Reporter" and "Golfdom."

Materials and Methods

Certain revisions were made in the 1955-56 study. These were as follows:

(1) *Chemicals*—only one rate of each chemical was used—PMAS at three (3) ounces of 10% material per thousand square feet; Calo Clor at three (3) ounces per one thousand square feet. In earlier tests, PMAS was used at one and one-half (1½) and three (3) ounces per thousand square feet, and Calo Clor at two (2) and four (4) ounces per thousand square feet.

(2) *Carriers*—Processed sewage sludge—Milorganite at the rate of fifty (50) and one hundred (100) pounds per thousand square feet, topdressing at a volume equal to one hundred (100) pounds of Milorganite, a mixture of topdressing and Milorganite at a volume equal to fifty (50) and one hundred (100) pounds of Milogranite, and water as a spray, were used as carriers.

Sand was omitted from the test in 1955-56. Earlier studies had shown the sand to be of little value, other than providing additional bulk for spreading the chemical.

(3) Milorganite, topdressing and a combination of the two materials were used without chemical.

(4) A series of plots received soluble nitrogen from an inorganic carrier (ammonium sulfate) at a rate to equal the amount of nitrogen contained in one hundred (100) pounds of the organic carrier—Milorganite.

The treatments were replicated three times. They were applied in late November only.

Effectiveness of the various chemicals and carriers were measured by recording the actual number of snowmold spots which devoloped during late winter and early spring. Color ratings were also recorded during this period. Two or three thaws and subsequent snows occurred, thus providing excellent conditions for evaluating longevity and persistence of the various chemicals and carriers.

The 1955 snowmold control program at the Somerset Country Club, St. Paul, Minnesota, although not an integral part of these experiments, serves to illustrate the practical application and to support the validity of the test results. Following a fall topdressing, the greens were treated in late November, early December, with four ounces of Calo Clor mixed with ten pounds of Milorganite per thousand square feet. The results of this program are presented in the discussion phase of this paper.

Results

Results of the 1955-56 test at the Toro R. & D. Center show:

(1) Three ounces of Calo Clor per thousand square feet produced effective control of snowmold, irrespective of carrier.

(2) The three ounce rate of PMAS was effective against snowmold under

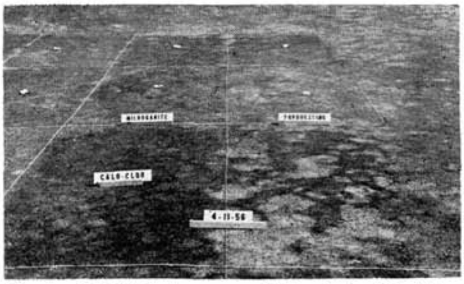

Fig. 1—Plot (left foreground) treated with Milorganite and Calo Clor. Plot at right treated with topdressing alone. Note color and freedom of disease on treated plot. Note also color of the disease-free grass on topdressing plot in contrast to that beyond test area, and on the spray plot located immediately behind topdressing plot.

Fig. 2—Plots treated with Calo Clor and PMAS as indicated. Milorganite was used as carrier for both chemicals. Note development of disease along plot borders. Second plot in rear of PMAS plots is a check—no treatment. Note severity of snowmold infestation.

normal environmental conditions. Under heavy and persistent snow pack and in low areas where moisture persisted—extreme environment—as on some plots, PMAS failed to render control, irrespective of carrier.

(3) Milorganite and topdressing produced earlier greening than spray treatments.

(4) Effectiveness of the Milorganite as measured by density, vigor and color throughout the growing season, was considerably superior to topdressing.

(5) Milorganite, topdressing, or the combination alone—without chemical—did not effect control of the snowmold.

(6) Soluble nitrogen (ammonium sulfate) produced severe damage resulting in almost complete destruction of the turf.

Some variation between the results obtained in 1955-56, and those of previous years are noted. These variations will be discussed.

Discussion

Check plots, as well as plots which received carrier alone—without chemical—were heavily infested with snowmold. See Figures 1, 2 and 3. The degree of infestation was less on plots receiving carrier alone than on the check plot (Figure 3). Nevertheless, the necessity of using a chemical effectively to control snowmold is obvious, since any degree of infestation is undersirable.

Calo Clor applied in late fall—early winter at a rate of three ounces per thousand square feet under the conditions studied controls the development of snowmold, irrespective of carrier or severity of environment (Figure 3). Effectiveness of Calo Clor may also be noted in Figures 1 and 2. Figures 4 and 5 show the effectiveness under field conditions. While the three ounce rate was satisfactory under controlled test conditions, it would appear that four ounces per thousand would be a more practical and desirable rate for golf course greens. It likewise appears that in the northern sections of the border states and

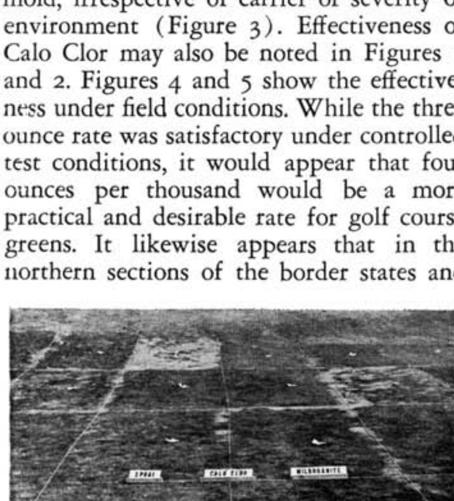

Fig. 3—Plots in immediate foreground treated with Calo Clor. That to left was sprayed; to right, Milorganite was used as carrier. Note contrast in color and freedom of disease. Check plot located three plots in rear of spray plot. Plot treated with topdressing alone—without chemical—located two plots to rear and one to right of Milorganite plot.

in Canada, an even higher rate may be desirable.

In the 1955-56 test, PMAS at three ounces per thousand square feet failed to produce the satisfactory control experienced during the previous years of the study. It should be pointed out that certain plots receiving PMAS were completely free of snowmold (Figure 2); nevertheless, the average infestation for all plots in all replications was such that the overall performance in 1955-56 was rated unsatisfactory. This average was materially influenced by the heavy infestation occurring on plots located in areas classified as having an extreme environment. The failure to control the disease on these plots is probably related to the soluble nature of phenyl mercury, since it appears that under normal environment, PMAS does render satisfactory control. Heavier rates, as well as retreatment with PMAS in late winter—early spring, may produce satisfactory control under all conditions.

Uniformity of coverage is essential for effective control of snowmold, This is illustrated in Figure 3, which shows the development of the disease along plot borders where treatments did not completely abut. Also, the development of disease along spreader borders where material was not lapped (Figure 4) and where the hopper was exhausted of material midway through one lap (Figure 5) illustrates the importance of uniform coverage. The evidence indicates that where carrier is used with the chemical, it is held in place with little to no lateral movement.

As noted, earlier spray applications are as effective in the control of snowmold as are those in which an organic carrier is used. The convenience of applying chemicals with available spray equipment may, under certain conditions, constitute an advantage for this method. It should be noted that the carrier may be applied dry and the Calo Clor sprayed over the material in place, as well as mixing carrier and chemical before application.

The major advantage of using an organic carrier appears to be the early greening produced. Plots receiving Milorganite and topdressing alone or in combination "greened up" some two to three weeks earlier than sprayed plots (Figures 1 and 3). This early greening may be partially explained by the thermal effects produced. The dark material absorbs and holds more heat; hence, raises the temperature of the micro-climate enough to permit early growth activity. The presence of available nitrogen at this time stimulates additional growth.

Other than the initial early greening produced by the topdressing, there appeared to be little advantage from using topdressing as a carrier. However, plots which received Milorganite alone or in combination with topdressing displayed continued superiority in density, color, and

Fig. 4—Green at Somerset CC topdressed in fall and treated in late November with four oz. of Calo Clor and 10 lbs. of Milorganite per 1000 sq. ft. Note development of disease along areas where spreader did not lap. Note also severity of disease on untreated apron and shoulder.

Fig. 5—Small area of bentgrass in fairway at Somerset C.C. treated with four oz. of Calo Clor and 10 lbs. of Milorganite per 1000 sq. ft. Note development of disease and lack of color in center swath where spreader was exhausted of material midway through run.

vigor in almost direct relation to the amount of material used.

The rates of Milorganite used in the 1955 test supplied three and six pounds of Nitrogen; in the 1953 and 1954 tests, twelve pounds of nitrogen; and the rate used at the Somerset Country Club in 1955, six-tenths (0.6) pounds of nitrogen per thousand square feet. In one series of plots in 1955, ammonium sulfate was applied at a rate to supply six pounds of nitrogen per thousand square feet.

It is highly significant to note that damage to the turf in the form of burning or over succulence from even the twelve pound rate of nitrogen from sewage sludge did not occur, whereas severe damage—actually almost complete kill—resulted from the use of six pounds of nitrogen from the soluble carrier (ammonium sulfate). The contrasting results can be attributed only to the difference between the rate of release of nitrate from the two types of carriers. The failure of the Milorganite treated plots to develop succulence and the resultant damage associated with this condition may be partially explained by the slow breakdown of the material. The application was made very late in the fall; low temperatures at that time, as well as during winter, prevented complete breakdown. Subsequent spring temperatures were such that decomposition proceeded rather slowly, with no apparent ill effects. The possibility exists that the grass may be able to utilize some of the early products of decomposition (amino acids) for its very reduced metabolic activity during its period of dormancy. The use of soluble nitrogen at materially reduced rates to produce early greening may be possible; however, the results of this study do not warrant a recommendation as to the rate or time of application.

In the central and southern extremities of the snowmold zone, it would appear that low rates—ten to twenty pounds—of Milorganite would be preferable to the higher rates—up to fifty pounds—which appear satisfactory in the more northern areas. Although the 100 and 200 pound rate of Milorganite gave satisfactory results, it is felt that a maximum of fifty pounds per thousand square feet is adequate. Higher temperatures and more infrequent snowfall in the central and southern belts would undoubtedly lead to a release of more nitrates than would be experienced in the northern belts. This conceivably could produce sufficient succulence which, when coupled with rapid drops in temperature, might produce damage to the turfgrass.

Conclusions

Based on the results of experiments and observations conducted at the Toro R. & D. Center for the past three years, the following conclusions regarding the prevention and control of snowmold on golf course turfgrass seem warranted.

1. Three to four ounces of Calo Clor per thousand square feet provides satisfactory chemical control of snowmold.
2. Spray applications of Calo Clor give effective control of snowmold, but grass takes longer to green up than when Milorganite or topdressing is used as a carrier.
3. Milorganite or topdressing may be applied and Calo Clor sprayed onto them with the same results as obtained from mixing chemical and carrier before application.
4. Ten to fifty pounds of Milorganite per thousand square feet will produce greening some two to three weeks earlier. Greens so treated will exhibit superior color, density and vigor for an extended period of time in almost direct relation to the amount of material used. Low rates —ten to twenty pounds—are sug-

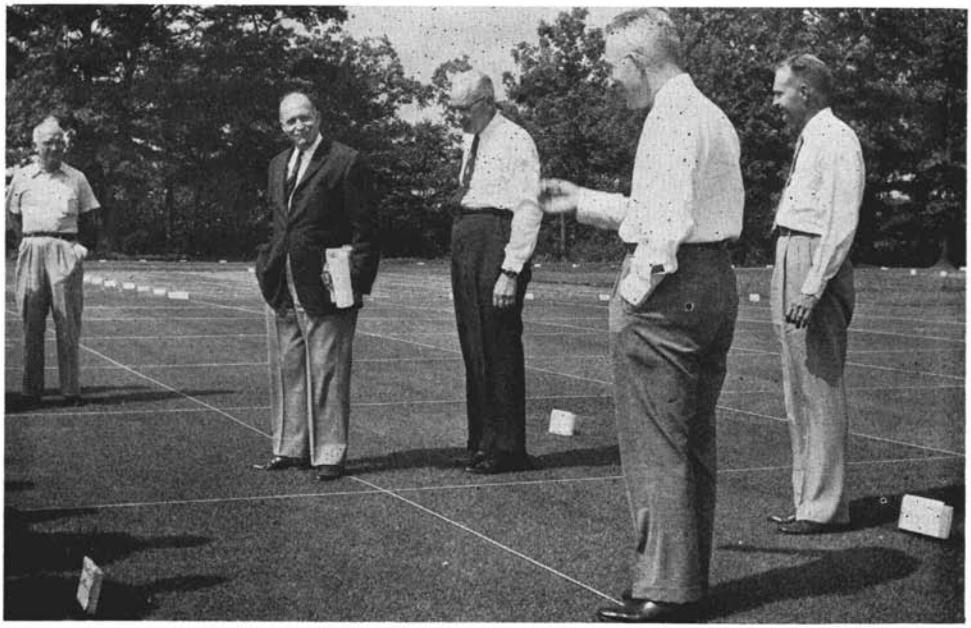

Photo by O. J. Noer

Experts gathered at the University of Rhode Island for the Rhode Island Field Day Meeting are left to right: Edwin H. Vare, Jr., Chairman, Green Committee, Philadelphia C.C.; Dr. J. A. DeFrance, Research Professor; Dean Mason H. Campbell, Director, Rhode Island Agricultural Experiment Station; Dr. W. H. Wiley, Associate Director, Rhode Island Agricultural Experiment Station; Dr. T. E. Odland, Head, Department of Agronomy.

gested for central and southern belts; higher rates appear satisfactory in more northern areas.

5. Topdressing used as a carrier produces eary greening, but fails to produce the improvement in quality experienced on Milorganite treated areas.
6. The combination of topdressing and Milorganite used as a carrier produces satisfactory results—early greening and superior quality. Prolonged superiority from a quality standpoint is directly related to the amount of Milorganite used.
7. PMAS (10%) used at a rate of three to four ounces per 1000 square feet may provide satisfactory control under normal conditions, but appears inadequate under extreme environment—heavy and persistent snow pack and low poorly drained areas. Retreatment in late winter—early spring, or possibly higher rates may be necessary to produce completely satisfactory control under all conditions.
8. Uniform application of any chemical is essential for satisfactory control.
9. Treatment of aprons, approaches and shoulders, as well as the green proper, is recommended. Such will protect the bentgrass present on these areas and possibly prevent invasion of weeds.
10. The results of these studies clearly indicate that from a practical standpoint, snowmold can be effectively controlled and greens brought into play considerably earlier by correct choice of chemical and carrier. Nevertheless, further research on all phases of this investigation are warranted. Fundamental studies are particularly needed on the effectiveness and retention of mercury vapors by humus and related materials, as well as the relationship between late fall—early winter applications of nitrogen and turf quality.