As this Review is being prepared plans are underway for an official release by the USGA Green Section and the U. S. Department of Agriculture of Z-52 strain of Japanese lawngrass (Zoysia japonica). Readers are asked to contact their own state experiment stations for information on this grass. Local recommendations vary because of climatic adaptation. In the so-called "crabgrass belt" Z-52 zoysia is able to crowd out crabgrass under ordinary lawn management.

Management

Studies of the proper use of fertilizer materials are among the most important pursuits of turf research workers. Many of the fertilizer practices that are now in use have been derived from the experience of turf users over a period of many years. Almost every experiment station that has been engaged in turf research has conducted one or more series of fertilizer tests under field conditions. Unfortunately, many of these experiments have not been well designed nor have they been conducted to yield data which could be used as a basis for determining proper fertilization practices.

In recent years, fertilizer and nutrient studies have been conducted by more refined experimental methods and a great deal of fundamental data have been developed. Greenhouse tests in which nutrient solutions were used to grow bent and bluegrass were first conducted at Arlington Farm by Dr. Mary E. Reid. Dr. Reid wrote an article for the October, 1933, number of the Bulletin of the USGA Green Section on the "Effect of Variations in Concentration of Mineral Nutrients Upon the Growth of Several Types of Turf Grasses." After her initial work, nothing further was done along this line until after World War II.

Purdue University, Rutgers University, and the USGA Green Section are among the stations which have done some of the most critical nutrient culture studies on turf. The work done by the Green Section has been based upon the assessment of the nutrient status of grasses by analysis of the clippings. Concentrations of nutrient elements in the leaves of the grass have been determined and correlated with the performance of the grass from the standpoint of vegetative growth and seed yield. It is proposed that data of this kind may be used as a basis for fertilization of turf grown in the field. The successful use of similar techniques in the growth of various horticultural food crop lends encouragement to the hope that improved turf fertilization practices may be derived from such studies.

The ureaform products have been the subject of a considerable amount of investigation. Both greenhouse and field studies have been conducted in which ureaform products have been compared with other nitrogen carriers. It is agreed generally that research findings indicate that there is a place in turf management for a product having the properties of the ureaform materials. Details of the practical usage of these products probably will have to be worked out in practice, but sufficient information is now available to serve as an adequate guide to the practical user of ureaform materials.

The years since World War II have seen a growing consciousness among technical workers and practical turf maintenance men alike on the dangers of overwatering turf. Much research has been aimed toward determining the detrimental effects of overwatering and toward working out criteria for determining the optimum irrigation

practices. Inasmuch as water usage is closely related to physical soil conditions, aeration, and drainage, all studies which deal with any one of these subjects necessarily touch on the other as well. No one of these phases of the environment of turf may be isolated and studied alone.

Research along these lines has been conducted at Purdue, Michigan, Pennsylvania, California, New York, New Jersey and Oklahoma. Additional work has been done by the USGA Green Section in cooperation with the Saratoga Laboratories at Saratoga Springs, New York.

The data which have been collected as a result of studies on irrigation, drainage, soil structure and aeration are voluminous and complex. The chief findings, however, may be stated quite simply. Briefly, they are (1) use only as much irrigation water as is necessary to keep the grass from wilting; (2) apply water slowly so that the soil is capable of absorbing the total amount applied without runoff; (3) cultivate as much as is practicable, to relieve compaction and to promote aeration and water absorption; (4) provide as nearly perfect drainage as possible; (5) modify soils (when it is practical to do so) so that the soil will not tend toward compaction, so that it will allow ready percolation of water, and so that it will be naturally well-aerated and well-drained.

Mowing heights for turf have been the subject of numerous research studies. Most of these studies have been prompted by earlier findings that amounts of root and top growth were correlated and the rationalization that higher mowing heights would produce better root systems and healthier turf. There are no data to refute these ideas. There are numerous indications, however, that physical soil conditions, moisture and nutritional factors have a greater influence on the extent of the rootsystem than does the height of mowing.

When turf is used for a specific purpose, the use determines the height of cut. There is no practical necessity for height of cut studies, as such. Therefore, investigations which have been conducted in recent years on this phase of turf management have had as their purpose the determination of whether or not a particular grass is suitable for turf for any particular use. Grasses which will not tolerate mowing heights of 1-1/4-inches or less are not suitable for fairway use. Many other examples could be cited.

The use of topdressing has declined considerably in recent years. Some excellent greens have not been topdressed in the last decade. The elimination of the practice of topdressing necessitates careful management of the putting greens by the golf course superintendent. Most superintendents will continue to use some topdressing even though the tendency may be to topdress less frequently.

The Rhode Island Agricultural Experiment Station has conducted investigations in the preparation of topdressing for many years. As a result of their work, it is now standard practice to incorporate 13 pounds of calcium cyanamid in each cubic yard of topdressing mixture. This practice eliminates practically all weeds in topdressing. The Rhode Island Station continues to study the effects of applications of various rates of topdressing and lime on putting greens.

The Georgia Coastal Plain Experiment Station has investigated the possibility of using sawdust as a source of organic matter in topdressing. Various

mixtures of sawdust, soil and fertilizer mixtures have been studied. Preliminary reports indicate that sawdust is an excellent material in proper mixtures.

Pest Control

Much effort has been expended in weed control research in the period since 1945. 2, 4-D has been an excellent tool for controlling broadleaf weeds. However, like many other management tools, it must be used properly. The use of 2, 4-D has now become fairly well standardized.

The crabgrass control materials are presently receiving the major emphasis in weed control studies. An article in the USGA Journal, February 1951 issue, summarized the present information with respect to crabgrass control.

Chickweed is one of the broadleaf weeds which is not controlled easily by 2, 4-D. Potassium cyanate has shown promise in some tests as an agent in chickweed control. Sodium arsenite has been used for this purpose for many years. Preliminary tests have indicated that a mixture of one pound of sodium arsenite and 8 pounds of potassium cyanate per acre will provide excellent control for chickweed and even lighter rates may be used effectively.

Most insects of turf may be controlled by either DDT or Chlordane. Both of these materials are relatively non-toxic to warm-blooded animals. DDT is an excellent material for the control of Japanese beetle grubs (25 pounds of actual DDT to the acre) and many of the surface-feeding insects, such as sod webworms, army worms, and cut worms (5 pounds of DDT to the acre). Chlordane is considered to be a more reliable and a quicker-acting material for the control of most of the surface feeding insects than is DDT. It is considered to be a more effective agent in the control of white grubs in the soil (10 pounds of technical Chlordane to the acre is standard).

The two stations which have conducted the major part of the research on insects of turf are the Connecticut Agricultural Experiment Station and the Florida Agricultural Experiment Station.

While earthworms are not insects, they may be controlled by using the insecticide Chlordane at the rate of about 10 pounds to the acre. While this amount of Chlordane may not actually kill all the worms, it appears to be effective in reducing the worm population so that worm casts on greens are not a serious nuisance.

The early research on turf diseases was done almost exclusively by the USGA Green Section. This phase of turf research probably has been pursued more avidly and with a more scientific approach than any other. Mercury treatments for brownpatch and dollarspot and Tersan treatments for brownpatch were developed by the Green Section.

More recently, agricultural experiment stations have begun to investigate disease control methods. The Pennsylvania Agricultural Experiment Station and the Rhode Island Agricultural Experiment Station have been the leaders in this work. The cadmium materials have come into use for the control of dollarspot as