of competent investigation determining true value. On buying seed, Quaill remarked:

Grass seed is another item which can run up costs very fast. Cheap grass seed is cheap grass seed and nothing else. Good seed is good seed and a lot more. It is insurance that it will grow and produce a good turf. Why buy a seed with a germination percentage of 60% for $30 per hundred when you can buy an 80% seed for $35 per hundred and get better results? Buy your seed on the basis of a guaranteed analysis and from a reputable seed house and you will have the satisfaction of knowing you are getting seed true to name and of the best quality.

One of the handicaps to economical maintenance is the pressure brought to bear on buying from members. He told of a case where 10 members of a club said they must have business from the watering system being installed or they would resign. The directors weakened and difference in delivery dates, character of pipe, checking up on orders and deliveries continually tied up the job and ran up expense. Extension of the installation next season was handled on a competitive bid basis. No member resigned and the club was saved considerable money.

Effects of staff reductions which do away with the niceties in course maintenance that identify a first-class course were pointed out. Results of pay cuts reducing efficiency and spirit of the staff also were mentioned as something greenkeepers must carefully guard against. He advocated changing tasks of men so they would retain interest and strongly advocated having all greensmen play golf. He said his own chairman gave him a valuable policy tip in labor management by remarking that when the greenkeeper was doing manual work it meant some one of the staff had been improperly trained or was loafing.

Quaill strongly emphasized the peril of procrastination in golf course work. In laying down his conclusion of making certain that enforced economies were not penny-wise and pound-foolish cases, he expressed himself thusly:

At this time practically every club in the country is retrenching and thinking out the financial problems which are confronting them. Now is the time for the greenkeeper to get his words in and tell where he thinks it best to start the economy program. Tell your chairman what you think and show him that you are not sitting back and letting them work out your problems. Tell him your ideas and I'll bet he will approve a bunch of them and give you credit for being wide awake and on the job.

Present Day Qualifications of the Greenkeeper

By O. B. FITTS

Greenkeeper, Columbia Country Club, Chevy Chase, Md.

VARIOUS educational campaigns of the past few years, said Mr. Fitts, have resulted in greenkeepers assuming responsibilities which formerly were on the shoulders of the green-chairman, golf architect, construction engineer and other experts and specialists. In other years, the greenkeeper was a sort of foreman, carrying out all but the merest of routine work on orders of the green-chairman.

These educational campaigns, however, have awakened the greenkeepers to the necessity of keeping abreast of the times, of gaining all possible knowledge of the many intricate phases of golf construction and maintenance, of becoming in fact earnest students of their profession. Changing standards, improved types of equipment, new turf diseases and pests have added to the greenkeeper's responsibilities and have given him an incentive to anticipate the future through study.

Take On Alteration Work

The speaker referred to the greenkeeper's part in course alteration programs, saying:

During the five years that I was with the U. S. G. A. Green Section I visited many golf courses. At many of these I found some change or alteration either in progress or under contemplation for the golf course. In most of these cases, especially if the alteration was to be of any consequence, the services of an architect had been or was to be secured for planning the work, and in some instances a construction engineer was also called into service. All of which was, in most cases in those days, the wisest thing for the club to do, for the average greenkeeper had not gone in for that type of work and was not qualified to handle it.

The story is different today, however, for the successful greenkeeper has made a study of the architectural and constructional phases of golf course work during the more recent years and has demonstrated his ability to execute any alteration of the course in a manner that satisfies the whims of the golfer and at the same time simplifies maintenance problems more than the work of some one who is not as familiar with local conditions. This knowledge and ability has made it possible for the greenkeeper to demand a better salary and at the same time effect a saving for his club.

Fitts outlined the intricate knowledge a greenkeeper must have to undertake alteration work. He must be a golfer so that the holes he designs are fair and sporting for expert, average and dub golfers alike. He must know landscaping, so the final result will be pleasant. He must remember the factors which make for economical maintenance. He must understand soils and drainage and irrigation, and must be familiar with various types of grasses, so that playable turf grows on his fairways and greens.

Becomes Purchasing Agent

The rise of the greenkeeper as a purchasing agent was next discussed, Fitts saying:

One of the greatest responsibilities which the rise in the standard of greenkeeping has placed in the care of the greenkeeper is that of purchasing equipment and supplies for the golf course. Not so many years ago practically everything for the golf course was purchased through the secretary of the club at the request of the green-chairman. All advertising matter was sent to these officials, and when a salesman visited a club he called on these officials. The result was that the greenkeeper knew what he was getting to use on the golf course or to work with only when the delivery man arrived with it. The greenkeeper has probably always had the privilege of asking for what he wanted or needed, but that was about the extent of his privilege and in many cases he never exercised this privilege, because the acknowledged subordinate standard of his position placed him in a constant state of intimidation. There were exceptions to this rule, of course, but there were fewer exceptions to than adherents to the rule.

It would be difficult to picture the successful greenkeeper of today having to stand back and wait for his chairman to decide what he needed or what he should use on the golf course. Whom does the supply and equipment salesman call on today? Whom does he have to convince of the value and practicability of his product before he may hope to make a sale? Who decides on the kind of seed, fertilizer, etc., to use, and who makes the investigations as to price and quality? Who chooses the equipment needed for the work on the golf course? The answer to these questions is, in most cases at least, the greenkeeper. "Why the greenkeeper?" you may ask. Because it is he who has made the most thorough study of the needs on the golf course and it is he who has familiarized himself with the practical particulars of these products to such an extent as to enable him to make a more intelligent selection than the average green-committee chairman is able to do.

The greenkeeper must be a good salesman, too. He must sell himself to his chairman, convincing that superior that he is capable of handling every phase of greenkeeping to the best advantage of the club. He must sell the importance of the greens job to the membership as a whole, not only because such effort will prevent his being fired and a new man given his job, but also because the members' attention should be called to the excellent playing conditions they enjoy through his efforts.

The greensman must also sell himself to his laborers by setting up a fair but strict set of working rules. He must insist on his authority being respected and tolerate no insubordination. He should recognize the varying amount of efficiency in a group of workers and so apportion the work and pay that each man is most advantageously employed. Selling the grounds crew on the fairness of their working conditions makes them satisfied and interested.

Must Rebound from Set-Backs

A greenkeeper sometimes has to take a licking, said Fitts, and accept it only as a matter of past consequence from which to begin all over.

When a set of beautiful greens, the result of diligent and tireless effort, succumb to the ravages of disease and insect pests and to the uncontrollable conditions of nature, one must possess more than mere courage in order to pitch in again and go through all the tedious and patience-wrecking course of treatment necessary to bring them back to their former state of excellence. One must have that necessary desire to conquer, and an unfailing love for the beauty and fineness of quality which he expects to restore to his disease-ridden and insect-infested turf. The successful greenkeeper has trained himself in these qualifications and, though he may be somewhat down-hearted at times, he never quits.

The speaker closed his remarks by cautioning his listeners against the theory that the greenkeeper has progressed beyond where expert assistance is not frequently needed.

It is my sincere belief that the present high standard of greenkeeping would never have been achieved except through the cooperation of men who are specialists in their respective fields. I also believe, just as sincerely, that we must have the cooperation of green-committee men, golf course architects, construction engineers, scientists, and trained investigators if we expect to progress. We have learned the very important lesson of how to cooperate with these men to get the greatest benefit of their knowledge. And having learned this lesson we must never under-estimate their indispensability to our future success.

Soil Conditions and Root Development

By HOWARD B. SPRAGUE

Agronomist, N. J. Agricultural Experiment Station

ROOTS ARE vital to plants—they provide anchorage, store food and absorb water, nitrogen and minerals. For this reason, Dr. Sprague explained, it is extremely important that cultural practices be governed just as closely by root demands as by the requirements of top-growth.

While anchorage and food-storage functions of roots are important, it is in the absorption of water and nutrients that plant roots are most vital to the plant. In this connection, the speaker pointed out:

Absorption of Water and Nutrients

Without the essential elements for growth, the permanent fixation of the plant would be of little value, and there would be no food to store. Quantities of water absorbed by plant roots are far greater than ordinarily thought. It has been estimated that on bent greens of average quality, the grass roots must take up during the growing season at least 3,750 gals. of water for each 1,000 sq. ft. of green. On Kentucky blue — redtop fairways, the amount absorbed by roots during the season is approximately 186,000 gals. per acre. In other words, the plant must take up 300 to 500 lbs. of water for every pound of dry substance formed in leaves, stems and roots.

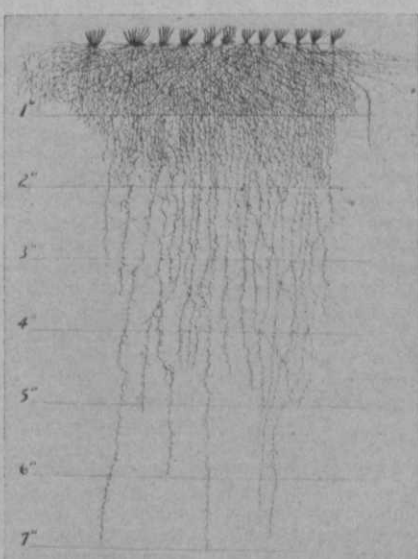

Fig. 1. Typical distribution of roots at various depths, for grass on putting greens

With regard to nutrients, the roots of fertilized bent putting greens must absorb, for each 1,000 sq. ft. of surface, nitrogen equivalent to that found in 15 lbs. of sulfate of ammonia, phosphorous equivalent to 12 lbs. of superphosphate, and potash equivalent to 6 lbs. of muriate of potash. On healthy Kentucky blue—redtop fairways the nitrogen absorbed per acre equals that found in 400 lbs. of sulfate of ammonia, phosphorus equal to 200 lbs. of superphosphate, and potassium equal to 200 lbs. of muriate of potash.

Both water and mineral substances are held by the soil with some tenacity; consequently the roots must make intimate contact with every group of soil particles before the water and minerals in contact with these particles may be utilized.

Root Structure

Grass roots are admirably adapted for making contact with the soil particles (Figure 1). Fine roots develop in whorls at each joint of stems that are located at or below the surface of the soil. As a result here is built up a fine network of roots and their branches to form what is called a fibrous root system. This is very different from the tap root system of such plants as dandelions, dock, trees, etc. These fibrous roots of grasses do not live indefinitely, but usually die within a year or two and are replaced by other roots. New roots are formed most abundantly during the spring months after growth of tops begins, and death normally comes in fall or early winter.

If the individual roots or branches are carefully examined (Figure 2), it will be found that at the tip there is a root cap composed of loosely arranged cells which slough-off as the root grows and pushes between the soil particles; these cells acting as a lubricant much as would oil on a bearing. Immediately back of the tip, is the growing point where new cells are constantly being formed as the root elongates. After formation, the new cells soon begin to enlarge, and the effect is to increase the length of the root and push the growing point further into the soil mass. As the cells enlarge, some of them are modified to perform different functions. Near the center of the root, certain groups of cells become elongated and the walls are thickened for conducting water; others become adapted for the movement of foods, and both types together form the vascular strands or veins as they are called. Between these strands and the outer layers are the storage cells which comprise the

cortex, and the outermost layer of cells form the epidermis or protective coating. Certain of the epidermal cells are greatly elongated and become root hairs.

Root hairs are of great importance since practically all water and nutrients absorbed by the plant enter through them, very little passing through the epidermis. Moreover, root hairs are found on roots in a very limited zone just back of the growing tip, and the individual hairs have a relatively short life. New root hairs must be formed continually to maintain normal absorption. When the root hairs have died, the epidermis of the root at that region becomes impermeable and unable to function for absorption. Since root hairs are very easily affected by soil conditions, attention must be given to this relation. It has been estimated that the root hairs increase the area of contact with a soil by 10 to 15 times as compared with the same root without hairs.

The extent of the root system and the thoroughness with which it occupies the soil mass is determined to a great extent by the system of management followed and by the nature of the soil itself.

Soil Moisture and Aeration

Experiments have shown that within certain limits, a relatively low water content of the soil stimulates roots to greater development, and likewise increases the abundance of root hairs. For example, plants grown in a soil with a moisture content of 19% available water have a total root area 1.2 times as great as the leaves and stems, whereas similar plants grown in a soil with only 9% available water possess a root area more than twice as great as the tops.

Soils which are compact and poorly aerated will permit only scanty growth and this will be confined to the upper layers. On the other hand, when the soil is very dry, root development is retarded or may even cease, the above-ground parts being dwarfed accordingly.

With the artificial watering generally practiced, one may do much to modify root development. Keeping the surface soil too moist during the early part of the season when new roots are being formed will favor development of a relatively shallow root system. Under such conditions the turf will be easily injured by drought later in the season because of the small volume of soil from which moisture is obtained. On the other hand, reducing the quantity of water used, or withholding water as long as possible will promote a deeper root system if other soil conditions are favorable for growth. Waterlogging the soil even temporarily may cause the death of roots in the flooded soil layers. Certain grasses are more tolerant of over-watering than others, but all of the better species are injured by such conditions.

The critical factor in cases of waterlogging and over-watering is usually not the excess of water, but the absence of sufficient oxygen for plant growth in the pore spaces of the soil.

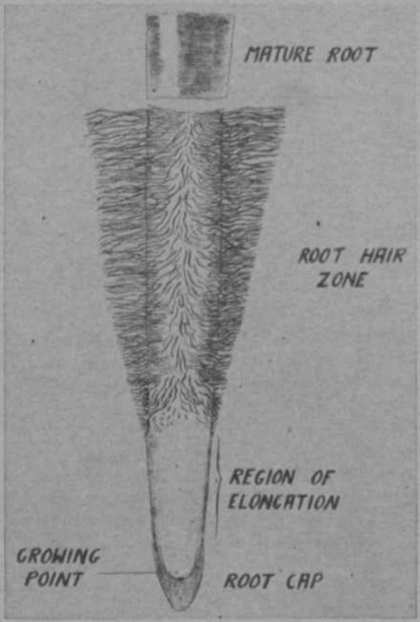

Fig. 2. Enlarged view of young grass root tip. Root cap protects growing point and acts as lubricant as root pushes through soil. Root hairs absorb practically all water and nutrients required by plant

Little if any growth of roots occurs when soils are frozen. Growth of our northern grasses begins soon after the soil temperatures reach 40° F. However, the soil does not warm-up in spring as soon as the air, and the deeper layers are slower in warming than the upper layers. Therefore, little root growth is made until the mean daily air temperatures are at least as high as 45° F. Soils that contain a large amount of water are much colder in spring than well aerated soils which contain smaller amounts of water.

Nutrient Supply

Supply of nutrients in an available form in the various horizons or layers of soil is an important factor in modifying the character of root systems. Roots branch more profusely in the soil layers that are liberally supplied with nutrients. Upon coming in contact with a soil layer rich in nitrogen, roots not only develop much more abundantly and branch more profusely, but they also fail to penetrate as far into the deeper soil.

On the other hand, the presence of an abundance of phosphates has been shown to increase root development strikingly. If phosphorous is deficient in soil, its application in an available form may be expected to greatly stimulate root length and branching.

Soil Acidity

Soil acidity and a lack of lime may also limit root penetration. The tolerance of turf grasses to soil acidity varies with the species, but all are injured to some extent by strong acidity. In some cases it may be found that the roots will penetrate only as deeply as the soil is freed of active acids. Soil acidity may affect absorption of nutrients and water even before it modifies root extent. This is due to the fact that root hairs are injured or destroyed by excessive acidity, just as they are killed by the presence of poisons in the soil water.

The extent of the root system can be considerably influenced during the period of its development by the height and frequency of cutting. Plants cut very short are able to manufacture only a limited quantity of food in the leaves. If the supply of nitrogen is abundant or excessive at this period, the tendency will be to produce luxuriant top growth without a corresponding root development. On the other hand, plants that are cut less closely may utilize considerably greater amounts of nitrogen without hampering the development of the root system. The critical point seems to be the ratio of carbohydrate food present in the plant to the supply of available nitrogen. An overabundance of nitrogen favors top growth and retards root growth. This relation is probably most important in early spring when roots are actively growing.

Dr. Sprague concluded by giving details and results of the studies made at New Brunswick, N. J., on which the preceding remarks were based. The study data will be found in March GOLFDOM.

Bacteria in the Growing of Turf

By DR. J. G. LIPMAN
N. J. State Agricultural College

PLANTS commonly used in greens are the specialized and selected representatives of their class, expected to thrive and to survive under conditions that would be fatal to most plants. Frequent, close cutting, stimulation and over-stimulation of root development, compacting the soil, and frequently abnormal moisture, temperature and aeration conditions represent an environment that is not normal. It is evident that this abnormal environment would weaken and ultimately destroy the most hardy of the turf grasses except as special devices and treatments be used toward offsetting the weakening effects of the treatment. Such devices and treatments must reckon with the presence and activities of bacteria.

Factors which affect the growth and vigor of turf grasses may be grouped under the heads of environment and in connection with the food supply of plants. Amount, character and distribution of organic matter is of major importance. Amount of organic matter directly affects the circulation of air and water in the soil, and, to some extent, its temperature. Everything being equal, the more organic matter in the soil, the greater the amount of water absorbed and held. It is possible, therefore, to create a supply of organic matter so large as to interfere with optimum root development. The quality of the organic matter is also of direct significance in that its composition and physical nature may favorably or unfavorably influence root growth and the activities of soil bacteria. Distribution of the organic matter is also a factor of importance, since the amount of it at different depths of the soil and subsoil control the circulation of water and air and, through these, the feeding of the plants.

Everything being equal, the deeper the root zone the more vigorous the plants and the greater their resistance to unfavorable changes in their soil and climatic environment.

Carbon's Part Important

Approximately 50% of the dry weight of grasses, and of other plants, is carbon, the element which makes up all but a small proportion of the entire weight of coal or charcoal. There is only about .03% of carbon dioxide in moisture-free air. Areas on which vegetation is flourishing draw heavily and repeatedly on this relatively small supply. Had it not been for the constant movement of air above the land surface the gases overlying any area on which forests, cultivated crops or grasses grow vigorously would become depleted of their carbon dioxide supply to a point where plant growth would be checked. It is fortunate that there is not only the circulation of air, but also the replenishment of carbon dioxide from the soil itself.

Actively developing plant tissues contain only 5 to 10% dry matter. The rest is water. Without adequate water supply growth of both roots and tops is retarded. It is not merely a question of the amount of water supplied by rain or artificially, but also of the circulation of water in the soil, its ability to lift water from lower depths, and its ability to allow water to move downward and laterally. Together with water supply, we must consider air supply, for, in so far as the space not occupied by soil particles or roots is filled with water, it is not occupied by air or vice versa. When the soil is saturated and water stands at the surface, there is no air in it except for the small amounts of air gases dissolved in the water itself.

Preventing Plant Poisoning

For the best growth of plants there must be an optimum relation between water and air in the pore space. Growing roots take something out of the soil water and something out of the soil air. The latter must move about freely enough to prevent such changes in the composition of the soil air as would be inimical to the activities of soil bacteria. When such inimical or unfavorable conditions arise, substances more or less poisonous to the plants may be formed. Types of bacteria, fungi, protozoa and algae objectionable to the greenkeeper might, under such conditions, become unduly prominent. They might interfere with the functioning of the roots of turf grasses and of the kinds of bacteria that are important in providing for a satisfactory supply of certain plant ingredients.

In the soil available plant food is both manufactured and dispensed, so that there is a more or less constant transformation of raw materials into finished products that plants can use, and there is also a transformation into material made unavailable. The manufacturing processes in the soil are carried on largely by bacteria and other micro-organisms. One of the plant nutrients prominent in promoting growth of tops and roots is nitrogen. Nearly all nitrogen in soils is present in combination with carbon, hydrogen, sulphur and other elements in the so-called organic matter. This, as is well known, consists of residues of plants, the cells of micro-organisms and of the remains of insects, worms and other soil-inhabiting organisms. They must be broken down and the nitrogen released in the form of ammonia and nitrates.

Make Plant Food Available

Bacteria and other soil micro-organisms are the living agency on which we depend for breaking down soil organic matter and for manufacturing ammonia, nitrates, sulphates, phosphates and other essential plant nutrients. Everything else being equal, the warmer the soil and the more favorable the conditions as to water and air supply, the greater the number of soil bacteria, the more intense their multiplication and activities and the greater the rate of plant growth. Soil organic matter which contains too large a proportion of carbon does not favor a large supply of ammonia and nitrates to growing plants. In soils of this character bacteria actively compete with the higher plants and interfere with their growth in so far as the supply of available nitrogen is concerned. The ammonia and nitrates of the soil solution are so rapidly taken up by bacteria and changed back into unavailable organic matter as to deprive plant roots of a sufficient supply of this important plant nutrient. To a lesser extent this will apply also to sulphate, phosphates, lime and magnesia. The greenkeeper, if he succeeds, so tunes up the biological machinery in the soil as to create optimum growing conditions for the plants in which he is interested.

Balance in Soil

Examination of the plant roots may show that they do not penetrate deeply enough, nor are they more or less symmetrically distributed. The fault may lie in the texture of the soil and subsoil. In that case, artificial drainage must be provided for. Otherwise, the use of chemical fertilizers may hinder rather than favor normal and vigorous root development. The greenkeeper must bear in mind that, in applying chemical fertilizers, he inriches the soil solution which bathes the plant roots. He may make this solution so rich as to corrode the root hairs and the fine rootlets. He may also swing the biological balance in the soil toward types of bacteria and fungi that would be detrimental rather than helpful. In his anxiety to maintain a sufficient supply of organic matter he may resort to the use of peat, which has valuable as well as objectionable characteristics. It is true that any organic matter, including peat, will open up heavy soil and make more compact loose, sandy soil. It will increase the water-holding power of the soil and improve the circulation of air in fine textured material. At the same time, the organic matter of peat is not readily usable as a source of food for bacteria. Hence, peat is less desirable than good compost for stimulating soil bacterial activities. There is another factor in the use of composts that should not be overlooked. In one sense, good compost is like yeast in that it inoculates the soil, supplies it with billions of bacteria and sets up fermentation of organic matter that results in liberating a more adequate supply of available plant nutrients. The question of soil inoculation for greens is one that has not received much study. It is not necessary to use composts for the purpose. It is conceivable that, in the course of time, we shall develop artificial inoculants that can be applied to greens as a means of accomplishing the various improvements that an active soil bacterial flora may make possible.

Stimulating Bacteria

The greenkeeper must remember that, when he uses sulphate of ammonia, urea, nitrate of soda or various mixed chemical fertilizers, he supplies raw material containing an important and essential constituent of plant food. But, whatever the kinds and amounts of these nitrogen salts that may be used for stimulating root development and top growth, we should not forget that bacteria, also, are stimulated by having these substances placed at their disposal. Being so stimulated, they effect a whole chain of transformations and changes that become evident in the rate of growth of the plants themselves.

The greenkeeper may overlook the fact that the various chemicals employed may tend to make the soil more acid or less acid; that he may deepen the root zone or make it more shallow. Overemphasis has been laid in the past on the desirability of using such chemicals as would make the soil strongly acid; in consequence, there are many greens where lime or other materials possessing the same corrective action is needed. But, there are different kinds of lime and there are differences as to the amounts of lime that need to be used in establishing optimum conditions in the soil both for the bacteria and the plants. A uniform procedure cannot be recommended because conditions afield are not uniform. The best we can do is to acquaint ourselves with certain fundamental facts which hold true under all conditions. If these fundamental facts are well understood, practice may be so adjusted as to meet the needs of any particular place and time.

Rebuilding and Resodding Greens and Tees

By JOS. WILLIAMSON

HASTILY and inexpertly built greens in which there is faulty general construction or lack of drainage, Mr. Williamson blames for many apparently mysterious turf troubles. Before rebuilding he advises greenkeeper to learn past history of old green and why it did not function properly. Greenkeeper should satisfy himself about reasons of the green's failure so he may profit by mistakes that have been made.

Williamson expressed belief that life of a putting green is far overestimated, stating:

When we stop to consider what a green goes through during the years of its use and what we have done to it, it is only reasonable to admit that its life is gone and we must renew the soil which has become wornout, poisoned, and lifeless. So under these conditions it is only natural after a few years the old green should be torn up and rebuilt."

In rebuilding, select soil on which grasses will grow and thrive mostly from soil itself instead of by irrational use of high-powered fertilizers, Williamson counseled. He strongly championed good compost pile as greens maintenance necessity. Lack of care in soil selection and preparation and excessive fertilization he held responsible for much greens trouble. For proper greens soil, he advised thoroughly mixing approximately one-third loamy, fibrous topsoil, one-third sharp sand that will not pack, and one-third humus such as old, rotted stable manure and peat moss or leaf mold with a little wood ashes. If sub-soil is heavy clay, he advised plowing it up and mixing in a few loads of clean fine cinders or common sand, then rough grading to approximate contour.

Emphasizing correct drainage, he advised following procedure:

Most greens as a rule are built sloping slightly to the approach, and in this case the drains should be laid crosswise of the green, the trenches dug about 18 or 20 inches deep at the start with a gradual fall to the main which would be on one side of the green, falling to the lowest corner and the most convenient outlet. The trenches should be on an average of 12 to 15 ft. apart and either 3- or 4-in. drain tile used and placed close together in a straight line making connections to the main with tees which are made for this purpose, and should be back-filled with 1½ in. crushed rock to within 10 or 12 ins. of the finished surface of the topsoil.

After the drains have been filled with the rock, the subsoil should be rough graded between the drain trenches and sloped a little from the center to the line of tile, taking care that there are no low pockets lying between the drains in the subsoil. However, I would suggest not to cover the rock with the subsoil, but to leave it open and let it be covered with the topsoil when you are filling the surface. This will give perfect drainage of the subsoil to the trenches, and the topsoil on the rock will assure a complete porosity from the finished surface to the drains below.

Next is the filling in of the topsoil. This is done by wheelbarrows on plank boards, taking care that the grade of the subsoil

or the rock in the trenches is not disturbed by the dumping of the soil.

After the fill with the topsoil has been finished and a fairly good grade given to the surface it should be given a thorough treading down both ways with the feet close together, to make it settle and firm the top ready to be raked and graded smoothly for the sodding.

Cut sod slightly beveled about 3 ft. long by 1 ft. wide for convenient handling, advised Williamson, who described precision methods for this operation. Cut to an even thickness of about ¾ in. and roll for easy laying. Cutting and laying should be coordinated operations for exact fitting. Provide long boards for wheeling sod and men to work on. This preserves grade of green. Start laying in straight line closest to sod pile; even edge of green later. Place boards for workmen on sod, facilitating packing of sod and eliminating necessity of extra rolling and tamping. Finish with necessary small patches and rub in topdressing with flexible steel mat.

Tee Rebuilding

Tee on natural ground is preferred if drainage is good. Few lines of drain tile 15 ft. or 18 ft. apart usually assure good drainage. Make drainage to back of tee. Fall of 1 ft. in 25 ft. provides good drainage, stance and appearance.

In building elevated tees avoid slopes so steep players have to climb and jump. Provide plenty of tee area in avoiding costly repair work.

Build tees with sides parallel to fairway and fronts square across proper line of shot.

When fill is being made, spread while dumping, in layers 6 in. or 8 in. deep to assure quick, even settling. Spread on layer of topsoil and trod down. In sodding lay sod lengthwise to within 1 ft. of outer edges. By leaving this 1 ft. all around the sod will have a better hold than if joined exactly at the edge of the flat top surface.

Course Maintenance and Budgeting

By JOHN MacGREGOR

Chicago Golf Club

LABELING course maintenance budgeting "a tool which will enable you to reduce outlay materially in the majority of cases without sacrificing playing conditions," Mr. MacGregor commented on timeliness of his subject by impressing greenkeepers with necessity of demonstrating they are "business men capable of conserving employers' money, yet giving results in time of need."

Budgeting, he said, means not only forecasting expenditures but carefully keeping track of costs to see forecasts have not been exceeded. Greenkeepers are fully capable of cost-keeping if given a "simple, efficient set of records whereby, in from 5 to 15 minutes at end of each day, labor and material charges can be properly distributed." He believed many greenkeepers shied from the work because of the wrong idea that it involved complicated accounting.

He drew parallel with clubhouse operations, saying:

Club officials generally recognize that if their club is to continue to operate, maintenance costs both on the golf course and in the clubhouse will have to be materially reduced. This cannot be done by cutting quality of food or the condition of the course, because that would cut down patronage—and we must have two things today—maximum patronage available and minimum operating expenses on all sides.

MacGregor predicted that greenkeepers who have not installed precise, simple system of daily costkeeping within 2 years will have difficulty in controlling costs and holding jobs. Budgeting, formerly a loose and approximate operation, the Chicago golf expert remarked, now calls for exact knowledge of daily, weekly, monthly and season costs of each maintenance detail.

To establish a simple cost-keeping system, MacGregor advised first organizing "yourself and your daily work. Have a system in your daily work—just like a factory. Allot to each man a certain task or combination of tasks. Estimate approximately the cost of each job each day."

Said the Wheaton Scot: "I hope never again to have to operate a golf course without my own figures to tell me constantly what I am doing and enable me to control costs." He further described his labor organization and cost-keeping as follows:

When you have done this, you have a foundation upon which to estimate labor costs for each month, and a total for the year. It is relatively simple to estimate how many men are necessary to maintain your course successfully and to allot each man a reasonable amount of work to do and see that the work is done efficiently. In other words, don't watch your men to see that they are working, but watch the men's work to see that it is done properly and in sufficient volume. This solves the problem of the superintendence of men over a widely scattered area to a greater degree than anything I have ever encountered.

This is a far more practical and economical method of operation than working men in gangs or crews. A man who has a certain amount of work to do either does that work on time and properly, or is replaced. It results, too, in the elimination of the unfit and the creating of a picked crew after a season's work.

Now when you have figured and estimated about how much money is necessary for labor, your attention must then be turned to upkeep—to fertilizers, fungicides, vermin eradicators, sand, gasoline, oils, grease, power machinery parts and repairs and other small items classed under miscellaneous. Estimate this approximately and then add to it the cost of labor and upkeep, and that will be your budget for the ensuing year.

Figure Emergencies

However, in view of the uncertainty of weather conditions and the always-present possibility of drought and insect pests, to play safe it is well to ask for $1,000 reserve fund which, while you don't intend to use it under normal conditions, will be there to prevent you exceeding your budget in case of emergency.

Now when it comes to the distribution of labor and upkeep, this is either a daily job or it is valueless. To accomplish this you keep a diary of your day's operations, and the cost of the different work done. It is surprising how simple it is to keep the cost of operation if you will carry a diary in your pocket and make your entries from it promptly.

With this diary it is simple to determine the cost of the different items. The next step is to have available a monthly cost sheet, and take the items daily out of your diary and distribute on these cost sheets as concisely as possible and in the proper divisions.

One way of handling the monthly cost sheet is to divide it into eight headings; for instance, green mowing and green sprinkling would be one heading. Enter separately all of your other major operations, including rough cutting, fairway mowing, etc., so each will be allotted a column.

Now if your entries are made daily, it is an easy matter to total from time to time and see how you are running against your budget. You will have this information if your green-chairman should want to know. And if he doesn't want to know, you should know anyway.

At the end of each month a greenkeeper operating under this plan knows from his own notes how much he is over or under his budget to that date. It is hardly necessary to call your attention to the fact that upkeep items are totalled once each month.

At the end of the year the different items in each group are pulled off and compiled on one sheet, and the total yearly operations submitted to the green-chairman.

Soil Structure of Greens

By KENNETH WELTON

USGA Green Section

COMMON practice in greens construction of the past was to put down various layers, such as cinders, sand, gravel and peat, between the topsoil and subsoil. Mr. Welton pointed out that this interferes with the natural rise and fall of soil moisture, prevents natural drainage and elimination of toxic materials from the topsoil. It is better to prepare a deeper topsoil on a sand fill. Where better drainage is desired, "lines of tile quickly carry away excess water and do not interfere with the rise of capillary moisture in the soil."

On the subject of topsoil from the golfer's point of view, the speaker said:

If the soil is as hard as concrete it is almost impossible for the average player to hold the green with a pitch shot. A great cry arises from the indignant players and the greenkeeper is forced to soften the offending greens by pouring water upon them until the soil is saturated and muddy. The players trample the greens while in this condition, the soil becomes more packed, and if allowed to dry is harder than ever. It is expensive to water greens frequently, but if that were the only disadvantage to keeping greens wet, very few clubs would object.

The truth is, however, that such greens are always going from one extreme to another. The players cannot tell from day to day how different putting greens will act. And more important still is the fact that good turf cannot be kept for long on greens which require such treatment.

The greenkeeper knows that the soil is porous and that these pore spaces should be filled with air since roots require an almost constant supply of oxygen. The greenkeeper also knows that the soil must be loose enough for the roots to grow and forage in search of moisture and plant food. If pore space in the soil is filled with free water for too prolonged a period the roots are affected and the plant sickens and dies. If the soil puddles and packs while wet it becomes a solid mass and the pore space, and hence the oxygen in the soil, is greatly restricted. If the soil becomes as hard as brick when dry the roots are sealed and cannot grow. Obviously a topsoil which exhibits the above characteristics is unsuitable both from the player's and greenkeeper's point of view, and we must select or mix a soil which is suitable.

The Green Section authority went into some detail to describe the three major phases of any soil's make-up—the physical, the chemical and the biological. The greenkeeper is concerned with all three, but mainly with the physical, since his cultural practices influence the other phases, provided always he has the proper soil texture and structure to begin with.

Welton had this to say on organic matter:

Organic matter plays an important part in the fertility of the soil. It is necessary for the microscopic life in the soil, and has a marked effect on the structure and water holding capacity of the soil. On account of the affinity of organic matter for moisture which is held within it, a certain amount of organic matter in finer soils increases drainage and loss of free water by keeping the finer particles from settling together into a more or less compact mass.

Advises Topsoil Test

It is surprising, the speaker declared, how few golf course constructors will bother putting their soils to a plasticity test before using them on a putting green, although the method of testing soils for this characteristic is very simple. He explained:

This does seem negligible when one considers that the putting green is not dug up or cultivated from year to year and hence there is little opportunity to improve the soil once the green is in turf. Also, many greenkeepers kick about the tendency of their putting greens to form a hard crust on the surface, but although they mix soil for top-dressing purposes many times a year they never go to the trouble of testing the soil except by its feel when it is in that fine floury condition just after it has been put through the screen.

Some soils examined while under the field conditions may appear open and friable and in excellent physical condition, but that is no guarantee that this soil will not become as hard as brick under putting green conditions. Other soils are highly fertile and desirable for agricultural or gardening purposes. But fertility is what a soil is capable of producing under best possible conditions and in the putting green these soils may loose the structure they were maintained under in the field and in the garden and become unfertile in the green. It is, therefore, advisable for the golf course constructor or the greenkeeper to subject his putting green topsoil to test.

Equal quantities of the various soils or mixtures should be procured while dry enough to handle. They should then be wet and puddled in a uniform manner. It is important that the samples be handled alike as difference in wetting and mixing may confuse the results. A practical manner of handling the samples alike is to pour a similar amount of each sample into a similar container. A quart of soil in a 12-qt. bucket is easily handled. Then add water slowly while mixing and churning with a stick until the soil will absorb no more water. If too much water has been used, a little more of the same soil can be added to take up the superfluous water. With a little practice it will be possible to bring each sample to such a condition with equal handling that it will just flow from the pail when agitated. No record need be kept of the amount of water added to the different samples; the point is to add enough water to put each of them in the same plastic condition.

Samples should then be poured into uniform molds. Little troughs of equal size may be made for this purpose or small flower pots or boxes of the same capacity, shape and material may be used. The tops of these samples should then be troweled to smooth them and the samples set under cover to dry. After a few days the samples may be removed from the containers and allowed to dry further. The time of drying of various samples should be noted. Samples containing too much organic matter will show up as they will take overlong to dry. After the samples are thoroughly dry they may be handled and it will at once become apparent if some samples are unfit for putting green purposes.

Soils too high in sand or organic matter, or both, will not stand handling and may break while being removed from the mold. Samples which exhibit too much cohesion will be difficult to break. Samples which took a reasonable time to dry, which could be removed from the mold without crumbling and which could be broken down readily between the fingers and thumb, are at, or approaching, the correct texture. It will be found by this method that about one-third of clay or silt loam soils mixed with a third coarse sand and a third organic matter such as cultivated peat, humus or ground peat moss, will approach the condition described.

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for additional condensed reports on NAGA speeches