Maintenance Practices of 1932

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IN THE years immediately preceding 1932, turf excellence was stressed without close attention to cost. In this respect, clubs did not differ from the average individual or business establishment, but last spring, faced with the certain prospect of reduced income, clubs endeavored to adjust expenses in keeping with probable revenue. Some clubs in smaller cities reduced the course to nine holes, and a few of the larger clubs with several courses, restricted play to one 18-hole course. The actual saving was not proportional to the reduction in playing area, because some semblance of maintenance was necessary on the abandoned holes to permit resumption of play with the return of better times.

O. J. NOER

One of America's most noted experts on ways and means of maintaining fine turf.

Most clubs met the necessity for economy by a general reduction in maintenance expense. Exact figures are not available, but in most districts the reductions were nominal in keeping with lower material costs and slightly lowered wages. Increased labor efficiency enabled some greenkeepers to dispense with a portion of the former maintenance crew. Greens and fairways received major attention, and where labor shortage compelled partial neglect, this was rightly confined to areas of lesser importance.

FORCING SUICIDAL CUTS IS DISASTROUS

IN A very few instances, new officers intent upon making a favorable financial showing during their term, attempted to force suicidal cuts in the maintenance budget over the vigorous protest of their thinking chairman and greenkeeper. If permitted and allowed to continue, the very existence of the club as a golfing establishment is endangered. Clubs which are faced with the necessity of curtailing expenses should consider carefully before reducing maintenance expenses below the absolute minimum required to maintain acceptable and playable turf. Such procedure is false economy, because the supposed savings will be more than offset by the future cost of turf renovation. After all, golf is the plea for the club's existence and the better players will not continue financial support unless greens and fairways are reasonably good.

The present financial plight of many supposed golf clubs is chargeable to lavish club houses with attendant high taxes, large interest charges, and huge operating costs. These clubs are faced with one of two alternatives. They can neglect the golf course, or dispense with superfluous club house activities. To jeopardize support of the playing members is most certainly fatal to the clubs' continued existence. The safer procedure is to eliminate all nonprofitable social functions, and reduce club house activities to bare necessities. This is not a plea for carte blanc extravagance on the part of Green committees and greenkeepers. It is their clear duty to cooperate by providing and following a carefully considered, economical budget which will provide good turf at reasonable cost.

Greenkeeping embraces two major activities, labor management and turf culture. The labor payroll is the largest single item of expense on the golf course. The methods of turf culture employed largely determine turf excellence. Some practices reduce, and others needlessly increase maintenance costs. Each year old methods are modified and new ones introduced. Some stand the test of time, while others are found wanting, yet clubs waste money needlessly each year by wholesale adoption of untried schemes. The wise greenkeeper is rightfully wary, and does not revolutionize accepted practice until the new proposal has been thoroughly tested.

This is the only justification for a survey of practices used in preceding years.

FAIRWAYS WERE HARD LAST SUMMER

DUE to limited rainfall, fairways were brown and hard throughout the most important part of the 1932 playing season. The St. Louis district was a notable exception, as rains were general during August. On some of the courses, fairways were ruined, for abundant moisture encouraged crab grass to form a solid mat, and thus smother and crowd out the blue grass. Fear of this fairway pest dampened the ardor for fairway irrigation in that district.

Lack of green fairways aroused keen interest in water systems in most of the other metropolitan sections. The marked contrast with nearby watered courses made the unwatered fairways look pitiful, and golfers clamored for water systems, often pointing to heavier play on the neighboring watered course, but gave no thought to the added burden of expense. It is certain that golfers on a number of courses will be greeted with watered fairways next summer, and all indications for the future point to more general watering to appease the player.

Opinions differ as to the best type of water system, but the choice seems to have narrowed to two, either the so-called one-man high pressure system, or the modified hose system. With the one-man system high pressures and large volumes of water are essential. Water lines are installed down the center of the fairway with snap valves at appropriate distances. The large sprinklers used are supposed to cover the entire width of fairway, and only 5 to 7 sprinklers are needed. This system lacks flexibility, but is said to work satisfactorily. The main watering is done at night, and brown areas as they appear along the edge of the fairway are watered during the day with smaller sprinklers.

With the hose system, water lines are placed along the edge of the fairways, or down the middle, with appropriately spaced openings. Sprinklers are first set to cover the far edges, and then gradually dragged across the fairway. This system can be operated with less total volume of water and at lower pressures. It is more flexible, and initial installation is cheaper, but operating costs are somewhat higher. Before proceeding, clubs should consider all items, and then install the system best adapted to local conditions.

FAIRWAY IRRIGATION REQUIRES CLOSE STUDY

FAIRWAY irrigation is not necessarily the panacea claimed by its most ardent supporters. True, it will provide a green turf and softer fairways throughout the playing season, but it necessarily complicates fairway management. The solution to some of the problems appear simple, but others will be more difficult.

Clover invariably spreads and becomes objectionable on watered fairways, unless steps are taken to check its invasion. Golfers rightfully object to clover because good lies are never obtainable when the ball rests in a patch of solid clover. It has been clearly shown that clover control is largely a matter of nitrogen feeding. On blue grass and fescue fairways the problem is simple, but where poa annua prevails there is always danger of encouraging such soft, weak growth by heavy nitrogen feeding that the grass will succumb during excessively hot weather.

Poa annua reappears in the fall even though the area be reseeded with other grasses. Nobody yet knows just what the answer is to clover control on poa annua fairways. It may be a matter of changing the kind of fertilizer or time of application so the effects of the nitrogen will be minimized or dissipated before the next summer season, or it may be a matter of changing water or cutting practices. These are mere conjectures, and the answer must await detailed and careful investigation.

The effect of water on crab grass has been mentioned. Its control with fairway watering is a matter of considerable moment in districts where this is a serious pest. There is some evidence for the belief that crab grass can be mastered, but as yet there is no basis for recommending a sure procedure.

When water systems were first installed it was believed that fertilization was unnecessary. The fallacy of this belief is now generally recognized. Fertilization and irrigation on greens supplement each other, and in this respect fairways are no different. Constant watering actually accentuates plant food losses by encouraging more abundant growth, and also enhances losses in the drainage water. Unless these losses are made good, gradual turf deterioration is inevitable.

On the other hand, fertilizers can be applied on watered fairways with positive assurance that there will be sufficient moisture to obtain full benefits.

Where water costs are high, proper feeding will slightly reduce the amount of water needed to maintain green turf, and thus effect a partial saving.

FAIRWAY FEEDING WAS NOT NEGLECTED IN 1932

FAIRWAY feeding was not neglected during 1932, and there is reason to believe that the practice was more general than in any preceding year. Opinions still differ as to what constitutes good practice. Need for nitrogen is generally conceded, but opinions vary regarding supplementary use of phosphoric acid and potash. A few believe a complete fertilizer should be used, others think nitrogen and phosphoric acid sufficient, and some claim nitrogen only is needed. From the standpoint of cost, this becomes a matter of importance on fairways. These different views can be settled only by careful, controlled trials, and until that is done, the only safe procedure is to follow practices which have been found to give satisfactory results.

Our own opinion may be subject to criticism, but nevertheless may be of some interest. Nitrogen is most important and turf cannot be improved unless it is used. Potash is seldom needed on heavy soils. Its use should be considered on very poor sands, peats, and mucks only. Need for phosphate can be judged by using one of the available soil phosphorus test kits now on the market, provided fairways have not been arsenated.

Where the supply of available soil phosphorus is high, phosphates are not needed, but where the soil supply is low, phosphates should be used. When phosphoric acid is required, applications every second or third year should suffice, for phosphorus is not lost in the drainage waters, and hence, interim feeding can be confined to nitrogen. Where complete fertilizers are needed, mixtures high in nitrogen with smaller amounts of phosphoric acid and potash are usually suitable.

FESCUE GROWS ON LOW SOILS

THERE is reason to believe that fescue will grow normally in soils too low in available phosphorus to support Kentucky blue grass. This may be one reason why fescue produces better turf in some of the northern districts where soils are acid and low in available phosphorus. If this belief is substantiated, it means that lower rates of phosphate applications can be used on fescue fairways with full assurance that satisfactory results will follow.

Some striking effects produced by lime were noticed on a few test plots. This was particularly true on blue grass, but similar effects were visible on some of the other grasses also. The limed grass was greener and appeared to withstand drought better, but the differences disappeared in the fall.

The past year witnessed an increased use of lime on acid fairway soils in the East. The present view appears to be that moderate liming of blue grass fairways on acid soils every three or four years may be justified. Where fescue and bent predominate, lime is not essential, and its use should be confined to more acid soils, and lighter rates of application are fully as effective.

ABOUT THE USE OF LIME

EARLY in 1932 attention was called to the fact that lime tends to render applications of lead arsenate for grub and earthworm control less certain. It is thought that lime converts the arsenate into a basic compound, and its effectiveness is thus lost.

This may partially explain why arsenate applications have not always produced desired results.

The incompatability of these materials raises an important practical problem in districts where fairways require lime for turf improvement and arsenate for grub control. Until investigation develops a better practice, it is believed that lime applications should precede the use of arsenate, with as much time as possible between the two applications, and that no more lime should be used than is absolutely necessary. The same principle obviously applies to greens.

Cutting practices on fairways received more attention, due to the findings of Dr. Harrison. Fairways have, undoubtedly, suffered as the result of severe leaf defoliation in the past. Player objection continued to be the greatest obstacle to somewhat longer grass. This is warranted only when fairways contain numerous cuppy depressions, for it is almost impossible to lift a ball out of these holes when surrounded by longer grass. To overcome player objection, fairway turf of uniform density must be developed. This is a matter of feeding, and in some cases supplementary seeding, for cutting, although important, is but one factor in turf improvement.

GREENKEEPER HAS NO CONTROL OVER WEATHER

WEATHER is a factor over which the greenkeeper has no control, yet it may simplify or complicate turf maintenance on greens. Its effects are not fully understood by golfers and club officials. They recognize the obvious need for supplementary water on fairways during dry seasons, but fail to appreciate or willfully ignore the dangers attendant upon their insistent and often unreasonable demand for soft putting surfaces and deep green color. Until their attitude changes, serious loss of turf on putting greens during unusual seasons seems inevitable.

Losses occur during hot, humid weather, and are accentuated when heavy rains accompany the heat wave. Troubles are most likely in wet seasons, such as 1928, but they may occur even in comparatively dry years. This was the case in 1931 when serious damage occurred during a brief period of unusual weather early in July. Turf loss may also occur when rain does not accompany hot weather, if over-watering is the rule, and the underlying soil is heavy.

From the standpoint of greens, 1932 weather caused very little trouble. There were very brief periods late in May and again in August with trouble in the making, but sudden changes localized injury to unusual greens, although in several instances poa annua fared badly. On several courses excessive use of water and too much nitrogen proved to be the undoing of turf on greens. In these cases, the underlying soil was too heavy for easy maintenance.

Since the greenkeeper cannot order weather to suit, severe turf losses can be avoided only by adopting practices which will produce sturdy turf able to withstand unseasonable weather. Each succeeding season since 1928 confirms the belief that this is possible, provided the underlying soil is not too heavy, and greens are not entirely poa annua, or planted with inferior strains of stolons. In 1932 greenkeepers paid closer attention to watering and feeding practices than ever before.

MIDSUMMER WATERING AND FEEDING MAY BE FATAL

DURING midsummer, generous nitrogen and copious watering must be avoided, because both tend to produce weak, soft leaves and stems. Such turf collapses quickly during periods of excessive heat, and the greenkeeper is helpless because there is no known quick remedy. The turf eventually recovers, but the process is necessarily slow, because new root formation must precede leaf development. It is useless to feed and water generously immediately following turf loss. This will retard rather than hasten recovery. Feeding is warranted only after the new root system is formed.

The tendency was to reduce nitrogen feeding to a point where the grass showed slight nitrogen hunger with the approach of summer, and then use light rates to barely hold color. In a few cases fear of producing lush turf deterred greenkeepers from applying sufficient nitrogen to prevent serious clover invasion. It may be better to err on the side of safety, but best practice is to devise feeding methods which will avoid disaster and yet maintain good putting turf.

At first thought a definite schedule of greens feeding would seem to be the simple solution. There are several valid objections to such procedure. Seasonal variations in weather affect rate of growth and need for nitrogen. Grasses differ in their re-

sponse to nitrogen. Velvets are very easily injured by overfeeding, and the better strains of stolon-planted bents become fluffy if too much nitrogen is used. Local differences between greens on the individual course necessitate different rates of nitrogen application. Grass on greens in sheltered locations grows slower, hence less nitrogen is needed. Color, rate of growth, and sturdiness are the safe criteria for determining rate and frequency of fertilizer application.

WATER PRACTICES SHOULD BE STUDIED

WATER practices received more deserved attention. During midsummer the amount of water was stressed more than the time of watering. Greens were kept moist, but slightly on the dry side. Overwetting, so water could be squeezed from soil pressed between the thumb and forefinger, was avoided. Greens in sheltered locations received closest attention, because they seldom dry out as rapidly as greens in the open, and hence need less water. Incidentally, restricting moisture supply tends to overcome the detrimental effects of too much nitrogen by reducing the rate of growth.

Controlling feeding and water practices not only minimized the danger of disaster, but tended to reduce the frequency and severity of brown patch attacks. This effected considerable saving because of the smaller amounts of fungicides required.

Spiking of greens was more general last year, especially during the hot summer months. Its advocates claim greens take water better following spiking, and that they are less apt to become water-logged. The practice probably has merit on soils which tend to pack, and to facilitate drying of the surface soil if it becomes water-logged as a result of excessive rain or over-watering.

Lime was more generally used on greens in districts where soils are acid. In most cases acidity determinations were the basis for determining its need. Finely-ground limestone or hydrated lime was applied, at light rates, sometimes in the late fall but more generally early in the spring. Very few courses in the midwest used lime. In most cases the high lime content of the sand used in the topdressing mixture supplied more lime than was required.

MORE INTEREST IN HUMUS MATERIALS

THERE is some evidence of increased interest in humus materials, to replace manure as a physical soil conditioner for new seedings, and as a constituent of the topdressing mixture. These materials show promise, provided they are properly used. No difficulties arise when they are incorporated with the soil prior to seeding, but when used in topdressing mixtures, some of the lighter, coarser products float out, and the particles gather in ridges or riffles during watering. This interferes with putting.

The trouble has been overcome in several instances by preliminary treatment of the peat before incorporating it with the soil and sand topdressing. The usual procedure was to mix small amounts of nitrogen with the peat, wet the mixture thoroughly, and allow it to stand for from one to two weeks. Partial breakdown produces a final product which does not riffle when used in topdressing mixtures.

The proportion of peat which can be used safely in topdressing mixtures has never been subjected to careful test. It is doubtful if more than 20 to 25 per cent of the finished topdressing should consist of these materials. Their tremendous waterholding capacity may make it difficult to prevent waterlogging of the surface soil during wet seasons, if the percentage greatly exceeds the above limit.

To date there is no evidence of general turf deterioration on golf courses. This is a tribute to greenkeepers and their committees. They cooperated with the club officials, and endeavored to maintain reasonably high standards. While it is certain the spending orgy of several years ago is at an end, this will not deter golfers from demanding high standards of maintenance. In the face of reduced revenues and the increasing complexity of turf culture, clubs who dispense with the services of competent greenkeepers are indeed pursuing a short-sighted policy.

What the future has in store nobody knows, but it is certain that the men who survive in their chosen life's work will be those who prove their worth. That greenkeepers are well aware of this fact is evidenced by their attendance at this convention.

Soils, Their Composition and Fertility

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MANY soil troubles experienced by groundskeepers are prepared for him before the course comes under his supervision. The desire to reduce construction costs results in the considerable use of whatever soil material is at hand, whether it be suitable or unsuitable. The foundation is thus laid for continuous trouble with ultimate reconstruction unavoidable so that the final total cost is far in excess of what the cost of proper construction in the beginning would have been, not to mention the inconvenience, worry to the greenkeeper and Green committee, and the criticism by players.

C. E. MILLAR

Who has practically every kind of soil in Michigan and understands all of them.

This idea is admirably expressed in the following quotation from Professor Dickinson: "On many of the younger courses (5 to 10 years old) the greens are failing physically because of hurried, careless, and low-priced construction."

I would not have you think, however, that the greenkeeper may lay all of his trouble at the door of faulty construction and then go blameless. He, as everyone else, makes mistakes and must take the consequences.

Men differ in personality and disposition. If you are to live harmoniously with your fellow men, you must take into consideration these differences in your dealings with them. Likewise, greens differ in their characteristics and you must consider these differences in your management of them. This idea is very aptly put in the following quotation from a recent editorial by Mr. Robert E. Power in the NATIONAL GREENKEEPER, "The greenkeeper knows his soil condition, his climatic condition, his exposures, his particular problems on every one of the 18 holes of his course. They are not all alike and if he treats them so, he is no credit to the profession."

It is not my purpose, therefore, to outline any specific procedure or to give any specific advice but rather to call to your attention some fundamental facts which may be of assistance to you in outlining your management program.

In the beginning let us examine the soil situation on a green. No condition could be more artificial than that existing in greens soil. It is watered copiously at frequent intervals, yet it must not get soggy. Above all, it must not dry out. It must hold ample water but not too much. The green is submitted to constant tramping, yet it must not get packed or hard. Neither must it be too springy. The soil must supply ample nutriment to support a luxuriant growth of grass, yet the diet must be balanced so as not to result in weakened vegetation, subject to disease attack and breakdown under unfavorable climatic conditions.

What manner of soil possesses all these qualities? First there must be a substantial framework to support the load but with plenty of space between the supports. For the main units of the frame we depend on sand, and sand of fair size, not fine sand. The intermediate members of the structure should be of organic matter or humus. This material gives a measure of elasticity, thus preventing packing. The remainder or filling material may be of silt with some clay and fine sands.

POROSITY MUST BE MAINTAINED

POROSITY must be maintained at any cost in order that excess water may escape easily and air enter freely. This point was stressed by John Anderson in his recent article. Many troubles may be traced to lack of porosity, many more in fact than can be attributed to excessive porosity. Many greenkeepers bemoan the fact that their soils are too sandy,

but they are much better off than the man who has to deal with heavy binding soil.

The kind of soil the foundation of a green is constructed of does not make a great deal of difference so long as a suitable thickness of surface soil is used. In various parts of the country we find greens with foundations of clay, or pure sand, or even of rocky material, and yet supporting fine turfs which are kept in excellent condition with very little trouble. On the other hand, you are all familiar with greens built on clay or sand which are always sources of worry to greenkeepers. The difficulty usually lies in an insufficient thickness of suitable surface soil. In making these remarks I am assuming that the conformation of the green permits of ready escape of excess water or that pockets are adequately tiled.

It is not an impossibility to maintain a good turf on greens having an insufficient thickness of surface soil or having surface soils containing too little or too much clay and humus. To maintain a satisfactory turf under such conditions, however, requires constant watching, much good judgment on the part of the greenkeeper, and infinite care in watering. Some excellent ideas on watering and drainage were brought out by President MacGregor in his recent article.

A reasonable percentage of clay in greens soil is desirable because the clay gives substance or consistency to the soil. It is the safety valve or regulator. It takes up plant food when an excess is present and gives it off when the supply is low. It has shock-absorbing qualities—buffer capacity we call it—that is, it resists change.

THE DIFFERENCE BETWEEN CLAY AND SAND

THE difference between clay and sand in their ability to resist change, that is, chemical change, may be crudely illustrated as follows: Let us suppose two barns, one having stalls for 24 cattle and the other for six cattle, are full of cattle. Now if six cattle are taken from each barn the one is empty while the other still contains 18 head and many cattle may still be supplied from it. On the other hand if both barns are empty and it is desired to get a herd of cattle in out of a storm, one barn is full when six cattle have been placed in it while the other barn is only one-fourth full when six cattle are in it. In other words, one barn is easily emptied or filled while the other, having much more capacity, resists filling and emptying to a much greater extent.

Now how does this apply to soil in a green? Suppose sulphate of ammonia is added to the green. The clay will immediately take up considerable quantities of the ammonia and gradually give it off later as the supply in the soil moisture is exhausted. A soil composed largely of sand will hold very little of the ammonia, however, allowing it to be carried away in the drainage water. Again, suppose some acid-forming material as aluminum sulphate or sulphur is added to the soil. A soil containing clay will resist the acid-producing effect and will be made only slightly more acid. On the other hand a soil composed largely of sand does not have the capacity to resist change and hence will be considerably increased in acidity.

Organic matter or humus also has some buffer capacity or resistance to change, but it is quite small compared to that of clay. On the other hand, very finely divided humus, similar to clay in size, does have a large capacity to take up and give off soluble plant food.

CHEMICAL CHANGE IN SOIL PARTICLES

AT FIRST thought one is inclined to consider soil particles as simply rock fragments of various sizes. This conception is probably true for the sand particles and to a certain extent for the larger silt particles. As the smaller silt particles and clay come under consideration we must, however, recognize that a considerable chemical change has occurred in addition to a reduction in size. The basic constituents, that is those substances or elements which have the power to sweeten or neutralize acids, are dissolved from the surface of the particles. This loss together with other chemical alterations results in the formation of a jelly-like substance which exists as a coating on the surface of the small particles. In fact the finest particles undoubtedly consist very largely of a sticky, jelly-like material which is the product or residue of the chemical breakdown of the original mineral fragments.

It is this gelatinous substance which gives clay its stickiness and causes it to shrink and get hard when dry. The ability to take up plant food elements and

hold them in reserve is also due to the activity of this glue-like material. The buffer capacity, or capacity to resist change is due to the presence and activity of this substance.

It is evident that a certain amount of this stabilizing material is desirable in a greens soil. On the other hand, too much of it is very objectionable, as you all know from experience. I might also remark that a little of this glue-like or colloidal material goes a long way. So dominant is it in imparting its characteristics to a soil that if 30% or even less were present you would all characterize the soil as a heavy clay.

The value of humus in the soil has been stressed by Mr. Williamson in his articles in the NATIONAL GREENKEEPER. Earlier in this paper I referred to the importance of humus or organic matter in giving resilience to the soil. Whether or not this valuable function is performed depends to a considerable extent on the nature of the organic matter used. Organic matter of a sticky, gummy nature, frequently found in sections of the country where muck beds occur, is not suitable for use in making surface soil for greens. Such material shrinks excessively when drying, becomes soggy and compact with tramping and in no way imparts to the soil the elasticity and porosity that is desirable.

Organic matter should be more or less fibrous to give to the soil the properties desired. If decay has proceeded to such an extent that the fibrous nature of the material is entirely destroyed it should not be used.

ABOUT TOP DRESSINGS

THE properties of a desirable top dressing soil are identical with those required of a good surface soil for as time goes by the top dressing material constitutes the upper section of the surface soil. This statement raises the question of whether or not different greens do not require top dressing of different quality. For example, should a green constructed of soil containing an excess of clay be top-dressed with soil composed largely of sand? I am well aware that there will be wide differences of opinion on this point.

You will agree, I think, that the sand should not be used in such a manner as to ultimately form a layer of virtually pure sand in the green. The detrimental effects of such a layer are familiar to all. If the sand could be thoroughly incorporated with the soil there would be no question of the advisability of its use. Whether or not this end can be accomplished without tearing out the green and rebuilding it is a question which can be answered only by careful trial.

The use of top dressing soil unusually rich in humus and sometimes clay has been advised on greens composed of very sandy soil. The same general criticisms may be made of this practice that were raised regarding the use of sand on heavy soil.

On the whole it is doubtful if much can be done in the course of two or three seasons to alter the texture of the soil after a green has been constructed. In general it may be better to use a soil of desirable qualities composed of proper proportions of sand, clay, and humus, regardless of the nature of the surface soil.

AUTHOR TESTS SOIL SAMPLES

THE question now arises as to what is the make-up of a desirable top dressing soil. To obtain an answer to this problem the writer procured samples of the top dressing soil being used by a number of quite

successful greenkeepers in Michigan—and, by the way, we have some mighty good greenkeepers in Michigan. These soil samples were taken to the laboratory and submitted to an analysis to determine their stickiness and the percentages of sand, silt, clay, humus, and water-holding capacity. The results are submitted in the following tables:

TABLE I

Soil No.	Humus %	Sand %	Clay %	Silt %
1	1.5	63.6	16.5	15.2
2	2.4	85.4	5.7	8.1
3	2.5	78.8	5.5	13.0
4	4.2	80.1	9.3	11.0
5	6.8	63.8	14.2	16.0
6	8.6	72.3	11.0	9.9
7	15.0	61.5	6.8	15.9
8	16.0	66.7	7.4	9.1
9	16.5	57.3	7.0	19.6
Average	8.1	69.9	9.2	13.0

The first point that attracts our attention in these analyses is the great variation in the percentages of humus in these soils. You will note that they are arranged in ascending order in regard to humus content. The variation, therefore, is from 1.5% in soil No. 1 to 16.5% in soil No. 9.

Now, why this wide difference in humus content? It is not because of a lack of available humus, because the first five samples come from sections of the State where ample humus in the form of muck and peat is easily obtainable. The answer must be, therefore, that these five greenkeepers consider the percentages of humus in the soils they are using best adapted to the needs of their greens. In the case of soil No. 2, I chance to know that the soil from which the greens are made is very heavy and the greenkeeper is endeavoring to improve aeration and drainage by using a spike disk and applys a very sandy top dressing. You will note that his soil is the most sandy of any, having a total sand content of 85.4%.

The greenkeepers using the last three soil, 7, 8, 9, evidently consider from 14 to 16 per cent humus more desirable than 8 per cent or less, at least for the greens on the courses they are managing.

It is noteworthy that the percentages of sand run from about 60, 57.3 to be exact, to 85.4, with only one sample exceeding 80%. There is evidently much closer agreement as to the desirable percentage of sand than of humus for while soil 9 contains eleven times as much humus as soil 1, soil 2 only contains about one and one-half times as much sand as soil 9. Very presently we will examine the sand in these soils more in detail to get an idea as to how coarse the sand should be.

CLAY SEEMS TO BE DESIRABLE

THE percentages of clay in these soils indicate that these greenkeepers appreciate the value of a reasonable percentage of this material. Soil No. 1 deserves attention. You note that even though it is very low in humus it is also one of the lowest in sand content but is the highest in clay and contains a goodly percentage of silt. I will venture that this soil is fairly sticky and gets decidedly hard when dry. It is my opinion that the continued use of this soil will lead to difficulty.

As might be expected the percentages of clay vary much more than the percentages of sand but are much more uniform than the percentages of humus. The average percentage of clay, omitting soil No. 1, which is quite unusual, is 8.36. You will recall that I have referred to clay as the stabilizing component in soil, that is, the material which gives it buffer capacity. A reasonable quantity of clay is highly desirable but clay is so potent in impressing its characteristics on a soil that more than a moderate percentage is to be avoided.

Considerable variation in the silt content of these soils is not surprising. Silt has little stickiness when wet and yet it is not friable and porous as is sand. It adds body and considerable firmness to a soil without the danger of sogginess or hardness. With a reasonable percentage of humus, considerable silt is desirable in a green's soil but in combination with any large quantity of clay and especially with a low humus content it is dangerous since it tends to accentuate the clay properties. In general I would say that if the humus content runs below 9 or 10%

the clay and silt content should not exceed 25 or 30% unless there is more silt than clay.

STICKINESS OF SOILS

THE stickiness of these soils in relation to the percentages of clay and humus present should prove an interesting study. This data in addition to the percentage of maximum available water retained is presented in table 2.

TABLE II

Soil No.	% Clay	*Stickiness	% Humus	% Maximum Available Water
1	16.5	12.7	1.5	28.8
2	5.7	2.4	2.4	24.5
3	5.5	0.0	2.5	37.3
4	9.3	2.4	4.2	34.0
5	14.2	0.0	6.8	36.2
6	11.0	0.0	8.6	30.2
7	6.8	0.0	15.0	55.3
8	7.4	0.0	16.0	72.8
9	7.0	0.0	16.5	50.6

*Pounds per 10 square inches at one-half maximum available water content.

It will be observed that soils 1, 2, and 4 are the only ones exhibiting any stickiness at one-half the maximum available water content. The stickiness of soil No. 1 is outstanding as was predicted from its clay content in conjunction with the meager quantity of humus. The percentages of clay in soils 2 and 4 though not large are sufficient to give a slight stickiness because of the small humus contents of the soils. The efficiency of humus in overcoming the tendency of clay to make soils sticky is well illustrated in soil No. 5. Despite the comparatively high clay content of this soil it exhibits no stickiness even though it is one of the lowest in total sand content.

Considering the low humus content of soil No. 3 in association with a clay content virtually equal to that of soil No. 2 the question arises as to why this soil does not exhibit a slight stickiness. The answer may be found in the percentage of silt which is 13.0 as compared to 8.1 per cent in soil No. 2.

HUMUS AND CLAY HOLD WATER

THE influence of humus and of clay in increasing the capacity of soils to retain available water is well set forth in this table. The high clay content of soil No. 1 in combination with the 15.2% of silt give this soil a very appreciable water-holding capacity despite the fact that it contains a negligible quantity of humus. The capacity of humus to impart water-holding power to soils is well illustrated by a comparison of soils 1 and 4. With little more than half the clay content of soil 1, soil 4 holds 5% more water due undoubtedly to its higher humus content, which nevertheless is very low for a topdressing soil.

The high water-holding capacity of soil No. 3 immediately attracts attention in view of the low percentages of clay and humus. The very high content of very fine sand, 35.2 per cent in association with 26.1 per cent of fine sand undoubtedly accounts for the water-retaining power of the soil.

The tendency of fine and very fine sand to increase water-holding capacity of a soil is again illustrated in soil No. 8. In this case 37.2 per cent of fine sand and 23.4 per cent of very fine sand in conjunction with 16.0 per cent of humus give the soil the enormous water-holding capacity of 72.8 per cent. Soil No. 9 with slightly more humus retains only 50.6 per cent of water because it has only a moderate percentage of fine sand as will be seen from table 3. Tables 2 and 3 should really be considered at the same time, and I will call attention to some of these points once more as we study table 3.

Now let us turn our attention to the dimensions of the sand particles found in these soils.

TABLE III

Soil	Total Sand	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand
1	63.6	0.6	8.1	24.8	22.1	8.0
2	85.4	3.4	12.8	38.2	24.4	6.6
3	78.8	1.0	3.7	12.8	26.1	35.2
4	77.8	5.3	32.5	33.2	6.3	3.7
5	63.8	0.9	3.7	22.4	30.9	5.8
6	72.3	1.8	3.5	20.9	28.2	17.9
7	61.5	2.6	6.1	16.7	23.2	13.0
8	66.7	0.9	1.0	4.2	37.2	23.4
9	57.3	2.0	4.6	12.1	18.4	20.3

A glance at this table shows there is no uniformity in the size of the sand in the different soils. The percentage of fine gravel is small in all cases as it should be. It is noteworthy that with the exception of soil No. 3 the percentage of very fine sand is appreciable only in the soils containing the greater quantities of humus (Soils 6-7-8-9). Possibly this is a coincidence since the sand may have been associated with the humus in the natural state and not added to the compost as sand. At least the point is significant.