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THE GOLF GREENKEEPERS' ASSOCIATION

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KNOWLEDGE IS POWER

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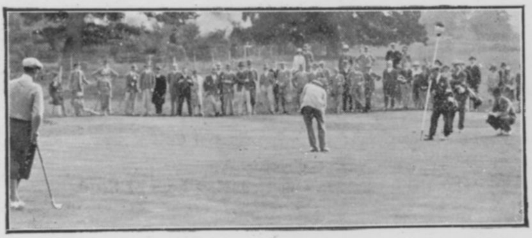
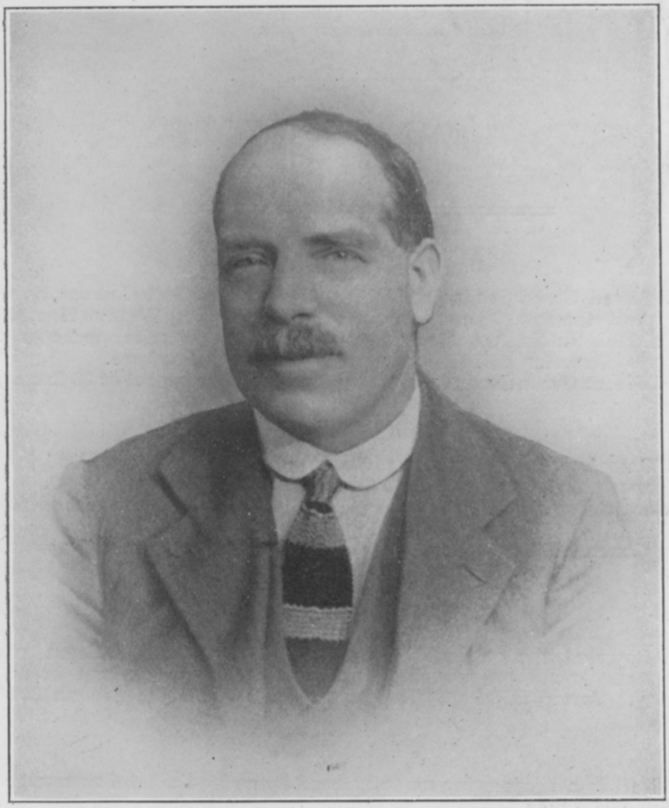




W. H. SMITHERS, Shirley Park G.C., Hon. Secretary.

Foreword.

THE Executive Committee have pleasure in again submitting to members the "Journal" of the Golf Greenkeepers' Association.

In this issue are reports of Lectures given by Mr. A. F. Wingfield, of Messrs. Sutton and Sons, and Mr. W. H. Fowler.

Members will find particular interest in the various articles by Mr. B. R. Leach, of Riverton, N.J. (the originator of the lead arsenate treatment of turf), while Mr. Norman Hackett, amongst other items, deals intensively with acidity of the soil.

The Executive Committee are greatly indebted to those eminent authorities on turf production whose articles in this "Journal" add so greatly to its value.

A copy of this "Journal" is sent post free to all members residing in the British Isles and abroad, whose annual subscription is not in arrear.

Surplus copies of 1927 and of this issue are now on sale to any recognised Greenkeeper and Golf Club, at 7s. 6d. and 10s. 6d. per copy.

The Executive Committee will not be responsible for the accuracy of the statements or conclusions contained in the several articles of this "Journal."

Any member willing to contribute an article on any interesting up-to-date greenkeeping subject for publication in the "Journal" is invited to communicate with the Hon. Secretary.

Papers not used will be returned to the writers.

W. H. SMITHERS.

Foreign Grubs, a Menace of the Future.

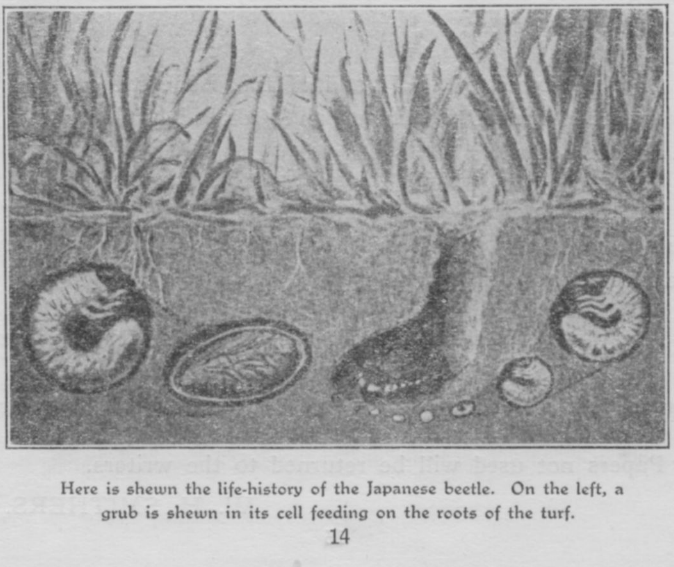
By B. R. LEACH,

Associate Entomologist U.S. Department of Agriculture and Consulting Entomologist U.S.G.A. Green Section.

Professor Leach discusses a grub-proofing compound that " can be applied to fine turf with impunity by the silliest jackass a golf course ever had the misfortune to have in its employ." If such is the case, greenkeepers and green-chairmen will be interested in reading what he has to say about this material—arsenate of lead.

IN a recent article I discussed in detail the life history of the Japanese beetle, and stated that the grub form of this insect had two weak traits in its otherwise invulnerable environmental armour. These two weak traits furnish the basis for my two methods of killing grubs by chemical means.

In order to emphasise the importance of these two avenues of approach upon which chemical warfare on grubs is based, it will be necessary to discuss briefly certain habits of the grub of the Japanese beetle, and, incidentally, with slight variations, the habits of other turf-infesting grubs, with the exception of the Green June beetle, *Cotinus nitida*. This last-named grub, being distinct in habits from the general run of turf-infesting grubs will be discussed separately later on in this series of articles.



Here is shewn the life-history of the Japanese beetle. On the left, a grub is shewn in its cell feeding on the roots of the turf.

The grub of the Japanese beetle, if carefully unearthed, will be found in the soil, curled up in a round cavity or cell slightly larger than its body. The grub, during the active feeding period, is constantly clawing the soil from one wall of the cell, and packing it against another wall of the cell with its body. Hence the location of the cell is constantly changing.

The grub does not resort to this chronic display of energy because of a propensity for travel. Rather, it shifts about in the soil because, by doing so, plant roots are exposed in the cell, upon which the grub feeds. The May beetle grub and other native species have the same system of feeding in a cell, travelling parallel with the surface of the soil, and, at whatever depth they may be working, cutting off the roots in a swath, without entirely consuming each root attached. The Japanese beetle grub, on the contrary, pretty well consumes each root it encounters, so that the progress of the grub through the soil is represented by a series of short, up-and-down travels, all lying within a certain distance below the surface, and made as the grub follows the individual roots from tip to grass-crown or vice versa.

During the grubs' active feeding-period, the depth from the surface of the soil at which they are found depends almost entirely upon one factor, viz., soil moisture. Grubs, as a general rule, heartily dislike soil which is at all dry, and they will rarely feed in it. This is, no doubt, due to the fact that dry soil does not pack well, and is not conducive to the maintenance of the cell. When the surface soil is moist, the grubs are up within half-an-inch of the surface; but let the upper half-inch,

A patch of putting green turf laid back to show a fairly heavy grub infestation.

inch, or two inches of soil dry out, and down they go until they reach a soil-layer containing a sufficient degree of moisture to satisfy them. If it should subsequently rain, or the turf be adequately watered, they quickly return near to the surface. The grubs, no doubt, prefer to feed close to the surface, because the greater proportion of the grass-roots in fine turf are located in this soil-layer.

GREENSMEN MUST FORESTALL GRUBS.

This root-cutting upon fine turf when a heavy grub infestation is present just under the surface, results in the ruin of the green or other turf area. The turf can be saved if taken in time, but the average greenkeeper never knows what has hit him until the grass begins to brown up. Of course, in the more heavily infested portions of the Japanese beetle area we have taught the greenkeepers to keep an eye on the turf from the 20th of July, onward, and, by pulling on the grass, to see if it is firmly rooted (if grubs are working it will have a loose, spongy feeling), and by occasionally making a two-sided cut here and there, and turning back the sod for a few inches, the degree of grub infestation can be determined fairly accurately. Greenkeepers who have not had experience with the grubs usually get burned at least once before they learn to read the signs.

With May beetle grubs and other native species, where several years may intervene between infestations in a given club, the greenkeeper tends to lose the habit of anticipating grub injury, but he will be well advised to always keep half an eye open for all strange beetles in his jaunts around the course, and, if in doubt, send specimens to his state experiment station. If they are defined as turf-feeders and are present in any appreciable numbers, watch the turf from then on for the presence of grubs, and apply the remedy before the grass is all shot.

TOO LATE WHEN GRASS WITHERS.

It is surprising how many letters I receive from greenkeepers in the course of a year's time, stating that they sending some grubs in a tobacco can, that the grass is dying, and what can be done about it. I certainly do wish sometimes that I could work out a method of making dead turf green again in twelve hours. Lacking such a method, however, the only alternative for the greenkeeper is to learn to anticipate grub injury, and to apply treatments before the turf is threatened. At this stage of the proceedings the grubs can be killed, and the grass will snap back into normal condition very rapidly. When the turf is definitely on its way west, all that can be done is to kill the grubs and reseed, or replant with stolons, as the case may be.

The tendency of the grubs to feed close to the soil surface when the soil is moist, is the key to the control of grubs in fine turf by means of the carbon disulphide emulsion method. For several days prior to treatment with this chemical, the green is thoroughly watered daily so as to keep the soil-surface moist. As a result, when the emulsion is applied the grubs are within a half-inch of the surface, and are easily killed with light applications of the emulsion, involving a comparatively low cost, and no injury to the turf. More will be said about this phase of the subject when I subsequently discuss the carbon disulphide emulsion method.

As stated above, the grubs are constantly moving about in the soil in search of food. Dissection and analyses made at the Japanese Beetle Laboratory have shown the make-up of food eaten by the grubs. Dissections were made of grubs collected from grass sod, and the contents of the fore part of the alimentary canal removed and analysed. It was found that the material eaten by the grubs consisted of small soil particles, fresh root-tissue, and small pieces of partially decomposed soil organic matter. Of the entire amount of material consumed, 64.3 per cent. by volume consisted of the roots of living plants, 15.7 per cent. was made up of partially decomposed organic matter, and the balance was soil particles.

The fact that grubs, during their active feeding period, are constantly eating roots and soil, coupled with the fact that they do this eating near the soil-surface, is the combination basis for the second method of grub control in fine turf by means of stomach poisons, such as arsenate of lead.

During the five-year period (1921-26), when the writer and assistants were working out the present method of grub-proofing turf, a large number of stomach poisons were tested out in order to determine their value in this connection. The list includes the arsenate of lead, calcium, copper, zinc, iron, and certain other metals, the various silicofluorides such as sodium, calcium, potassium, and barium, the cyanides of copper, lead, zinc, etc., and various mercury compounds, such as calomel.

ONLY ONE POISON EFFECTIVE.

The virtues of this list of chemicals, with the exception of arsenate of lead, as a means of grub-proofing turf can be dismissed with small comment. Calcium arsenate has no place in fine turf on account of its lime content. The remaining arsenates are either so stable in soil as to be non-toxic to grubs, as in the case of iron arsenate or they are so unstable and soluble that they are toxic to the grass, as in the case of copper and zinc arsenates.

The silicofluorides of sodium, potassium, and barium are first-class grub killing chemicals when used in soil, and almost all grasses will grow in soil so treated. Unfortunately, the silicofluorides have one extremely bad fault which inhibits their extensive use for the grub-proofing of fine turf. When they are mixed with soil and allowed to stand, some sort of a physical-chemical reaction of a cementing nature occurs between the chemical and the soil particles. If this were only of a temporary nature, it would not prevent the use of these chemicals in soil, but, unfortunately, the mild soil cement thus formed is lasting. When silicofluorides are used in sandy soil, the grass seed or stolon will sprout reasonably well providing the soil is kept constantly moist, but in clay soils they cannot push through the hard crust. As a means of controlling weeds in fine turf, the silicofluorides are not nearly as efficient as arsenate of lead. Crab grass and many other undesirable weeds grow well in soil treated with silicofluorides. It is unfortunate that this class of chemicals have this cementing action on soils, inasmuch as they could be made very cheaply from by-products of the huge fertilizer industry, and could be produced and sold at a relatively low price.

When the word *cyanide* is mentioned, one instinctively thinks of a deadly poison, but as a matter of fact the insoluble cyanides of lead, copper, zinc, etc., are a total loss as far as grub-proofing operations are concerned. Some of the mercury compounds, notably calomel, are good grub killers when mixed with soil, and are not toxic to grass, but the price is prohibitive. Spain has a monopoly on the world's supply of mercury, hence the high price.

Of all the chemicals tested over a five-year period, only one—arsenate of lead—possesses all the qualities necessary for grub-proofing fine turf. However, looking at it from a philosophical and practical standpoint, one is plenty.

What does it matter if all the other chemicals tested were found wanting in some respect? Ninety-nine per cent. of all research is negative as far as so-called practical results are concerned. It is that golden one per cent. of positive research results which makes the world go round. Research is very comparable to placer mining for gold. You have to handle a deuce of a lot of sand and gravel to secure a very little bit of that valuable yellow metal in the bottom of the pan, and, if you don't take care, you are apt to lose it in the last bit of sifting. The vast majority of research men are too dumb or blind to get their teeth into that elusive one per cent. It is also a deplorable fact that of those who do succeed in getting a mouthful, many are too doggoned lazy to chew. As a matter of fact, research men are born with the disease, they cannot acquire it; otherwise the universities would be turning them out to order by the gross.

Grubs which are beginning to feel the effects of the arsenic have a characteristic appearance as compared with a normal, healthy grub. The latter is always curled up tightly, with the head and tail close together, and the flesh is firm to the touch. Grubs begining to feel the effects of the arsenic, on the other hand, are soft and flabby to the touch, and are not tightly curled. They eat very little after the arsenic begins to take effect, and it is only a relatively short time before they succumb to the poison. In view of these facts, the significance of the word or expression "grubproof" is apparent when used in connection with arsenate of lead and fine turf.

Under these circumstances, we are concerned with the consideration of the best and easiest method of impregnating the upper soil layer of fine turf with arsenate of lead, so that any grubs finding their way into a turf so poisoned will react as described above. It will be necessary to divide the discussion into two parts: (1) Grubproofing greens and tees while in process of construction and before seeding. (2) Grubproofing established greens and tees.

GRUBPROOFING GREENS DURING CONSTRUCTION.

Build the green or tee and prepare it for seed or stolons just as you would if you had no intention of grubproofing it. All ploughing, manuring, discing, smoothing, and contouring should be done in the usual way. The area of the green should then be calculated accurately.

Most greens are roughly circular in outline. Compute its area by the following reasonably exact method. Look the green over and place a small wooden peg at the point you consider to be the centre of the green. Now take a tape measure, look the green over some more, and measure in a straight line the distance which you have decided is the longest distance across the green. In the same way, measure the distance which you decided is the shortest distance across the green. Let us suppose you find the longest distance across the green to be 72 feet, and the shortest distance 48 feet. Add these two distances together, making a total of 120 feet, and divide by four, which equals 30 feet. Multiply 30 by itself, which equals 900. Multiply 900 by 3.14, and this gives the approximate area of the green in square feet or 2,826 square feet. Now add 10 per cent. to this result, making the area of the green in round numbers 3,100 square feet. It is always wise to add this 10 per cent. to the calculated result, first, because most greens have an irregular outline, and, secondly, it never pays to be too tight with the arsenate of lead. A little bit extra will take care of the probable human error in calculation, and will make the grass grow greener.

APPLYING THE MIXTURE.

Presuming that the green or tee is all contoured and ready for the seed or stolons, we are now ready to apply the arsenate of lead. The green as measured above contains 3,100 square feet of surface. It will, therefore, require 15½ pounds of arsenate of lead, 5 pounds for each 1,000 square feet of soil surface treated. Inasmuch as arsenate of lead is a white, fluffy insoluble powder, and is blown about by the slightest puff of wind, it is not advisable to try to spread or dust it over the surface of the soil, because there will be a large loss due to the powder blowing away beyond the confines of the green or tee under treatment. Furthermore, it is a very difficult matter for the novice to dust 5 pounds of arsenate of lead evenly over 1,000 square feet of soil surface.

Under the circumstances it is advisable to mix the amount of arsenate of lead required for the green or tee with a quantity of *slightly* moist soil or sand. The use of heavy loam or clay is not advisable in this respect, as it has too great a tendency to lump. Apply the mixture of arsenate and soil to the green or tee before seeding. By following this method, loss of the chemical by blowing is largely prevented, and the increased bulk of the mixture enables the operator to cover the green more evenly and with less probability of error. The amount of soil or sand to be used as a filler for 5 pounds of arsenate of lead depends entirely upon the ability of the operator to spread it evenly over 1,000 square feet of soil surface. Some men, particularly those with many years of practical farming experience, can mix five pounds of arsenate of lead with a half bushel of soil or sand, and *sow* the mixture over the allotted area just as they would sow oats or rye, and with an exactness and evenness that is truly amazing. With the average workman of to-day, however, it will be advisable to use more soil or sand in the mixture, and let him spread it with a topdressing spreader. If this is not available, spread it by the handful out of a pail, allowing each handful to sift out from the fingers on to the surface of the soil.

DON'T SPARE THE MIXTURE.

A word of advice will not be amiss at this point. During the spreading of the poison mixture on the green, and especially during the novice's first attempt at this job, he will wake up when about two-thirds finished, and find that he is running short of the arsenate soil mixture. He immediately begins to suffer from a mild palpitation of the heart, and, provided the boss is out of sight, the little bit of arsenate remaining is made to finish the green. As a result, this portion of the green gets too small a portion of the lead arsenate it should properly receive, it does not grubproof the green, and, from that time on, "Professor" B. R. Leach is a bum, as far as that particular club is concerned.

Don't resort to such childish tactics. If you find yourself running short of arsenate of lead before you have finished applying it all over the green, mix up some more and finish the job properly. Incidentally, this will save me the necessity of answering a lot of fool questions when the club elects a new green-chairman the following year.

I made the statement that arsenate of lead could be applied by the silliest jackass a golf club ever had the misfortune to have in its employ. I meant by that statement that it is practically impossible to overdose with this compound. I have grown good grass in soil treated with 100 pounds of arsenate of lead to the thousand square feet of soil surface, or 20 times the dose recommended.

When the arsenate of lead has been applied to the surface of the green or tee as described above, take a rake, preferably a short-toothed one, and scratch the chemical into the soil to a depth of one-half inch, no deeper. This 5-pound dosage is based on a mixture with the top half-inch of surface soil. If it is scratched in deeper, more arsenate of lead will have to be used at the rate of 5 pounds for each additonal half-inch of soil depth. Hence, be careful with the rake, and don't become imbued with the idea that you are digging potatoes.

Here again let me emphasise the importance of having all contouring completed before applying and scratching-in the arsenate. This is fairly obvious, when one considers that the finished job calls for the upper half-inch soil layer *all over the green* to be impregnated with the poison. If the contouring is done after the application of the arsenate, it means that this layer will be removed in places, leaving places devoid of poison.

TURF GROWS SLOWER.

Having scratched-in the chemical as above, the seedling or planting of stolons can now be carried out in the usual way. If stolons are used, they should be covered with the usual *light* covering of unpoisoned soil.

Grass seed and stolons sprout somewhat more slowly in arsenated soil than is the case in untreated soil. The grass shoots are usually from 4 days to a week longer in making their appearance. Furthermore, they grow more slowly during the first two or three weeks. But after that period the grass catches up rapidly in growth, and in 60 days outstrips the grass in unpoisoned soil, not only in growth, but in colour and vigour.

The slowness of sprouting and growth in arsenated soil during the first few weeks is due to certain chemical changes which arsenate of lead undergoes in the soil. These changes, which are too technical to be discussed in a practical article of this sort, account for the slowing up in growth. Consequently, there is nothing to be alarmed about. As the grass becomes a little older and tougher, it reacts to the arsenate of lead in exactly the opposite fashion. Instead of slowing up the grass growth, the arsenate stimulates it. In fact, it would seem that less fertiliser is necessary for grass growing in arsenated soil. Part or all of this stimulation may be attributed to the action of arsenate of lead in discouraging certain soil bacteria and fungi, which are detrimental to the growth of fine turf grasses.

As the grass of the newly-planted green, grubproofed as above, continues too grow, the time comes when it is ready for the first topdressing. In order to maintain the grub-proof nature of the turf, all topdressing applied must contain arsenate of lead in the proper proportion, as the surface of the green is built up a sixteenth of an inch at a time by each topdressing. If this is not done, the original half-inch of poisoned soil will ultimately be buried under a constantly thickening layer of unpoisoned soil, and in the course of time, this unpoisoned soil will become sufficiently thick so that grubs can feed in it without ever getting down to the original half-inch of poisoned soil. The green will no longer be grub-proof. The system of grubproofing topdressing will be discussed in the next article, along with a discussion of methods to be followed in grubproofing established greens and tees.

How to Grub-proof Established Greens.

By B. R. LEACH,

Nature plays an underhanded game with the greenkeeper, and kids him into the belief that she is co-operating. She helps him to grow and develop a beautiful green until it is a sight for sore eyes, and, as a result, the average greenkeeper stands off to one side, takes off his hat, and says, " Ain't Nature grand."

There never was a greater fallacy in greenkeeping than this idea that Nature is on the side of the greenkeeper. She doesn't help him to develop that strip of luxuriant turf because she loves the greenkeeper or the game of golf. Not by any manner of means. Nature assists in this undertaking because she has ulterior motives; because she is making a first-class home for her illegitimate offspring in the shape of grubs, worms, weeds, and diseases.

From the day that a green is shaped up and in good playing condition, Nature does her best to ruin it. She gives the greenkeeper a battle every day of the year, and, until recent years, she periodically whipped the guardian of the greens to a standstill. As far as modern greenkeeping is concerned, the only way to make Nature respect you is to crack her over the snoot now and then with a hundred-weight of arsenate of lead or calomel. She doesn't understand this sort of fighting; it leaves her groggy and bewildered. And, in the meantime, your turf is safe.

SEVERAL years of experimental work, together with large-scale treatments made under my personal direction at several golf clubs in the East, have shown that 5 pounds of arsenate of lead per 1,000 square feet of turf will render it virtually grub and worm-proof, and greatly discourage the growth of noxious weeds. I know of one club near Philadelphia where the greens were adequately protected from a heavy infestation of Japanese beetle grub by a single application of only two pounds of arsenate of lead per 1,000 square feet of turf. This instance is not given as a dosage recommendation, but merely as an indication of the fact that a little arsenate of lead goes a long way in greenkeeping. Arsenate of lead is a relatively cheap chemical, and there is no object in cutting the dosage so low that a chance is taken on insuring results. On the other hand, if you want to gild the lily and perfume the rose by applying more than 5 pounds, it is quite all right. The grass will respond to the increased amount, and make a luxuriant growth, unobtainable from the use of fertilisers. I have grown good turf in soil containing 100 pounds of arsenate of lead per 1,000 square feet of turf.

Under the circumstances the danger of employees overdosing the turf need not give rise to undue concern. Be concerned only that each square foot of turf receives its share of the arsenate; in other words, insist on efficient and even application of the chemical.

In treating turf with arsenate of lead, it is poor business to dust, spray, or otherwise apply the chemical by itself. In the first place, arsenate of lead is a fluffy, impalpable powder, easily blown about by the slightest puff of wind. When, therefore, you try to dust it in, the powder blows about, and is deposited everywhere but where it is intended to go. Secondly, no novice can dust a small amount of the chemical evenly over 1,000 square feet of turf. Thirdly, the chemical sticks to the foliage if the blades of grass are at all moist, and may cause a surface burning. While this burning is only of a temporary nature, there is no sound reason for causing it. For this reason spraying is not advised.

HOW TO APPLY TO TURF.

One of the two best ways of applying arsenate of lead to fine turf is to mix it with moist, not wet, sand or screened soil, say one or two bushels to a green, and sow or scatter it over the green before or after topdressing. Do not use clay soil or heavy loam for this purpose, as it has too great a tendency to lump, thereby causing an uneven distribution of the chemical. By mixing with soil or sand in this way, the arsenate of lead clings to the soil particles, and sifts down through the blades of grass without clinging to them. In this connection, avoid applying the arsenate of lead to fine turf when the grass is wet. If you have an employee who can sow or scatter the mixture of soil and arsenate *evenly* over the turf, this method is the simplest and easiest. Otherwise, the second and following method, while involving more labour, is advisable.

ANOTHER METHOD.

This second method consists in mixing the arsenate of lead with the entire bulk of topdressing, and applying to the green as per the usual way. From experience, the greenkeeper knows just about how much topdressing he applies to each green. If the amount of arsenate of lead to be applied is mixed with the required amount of topdressing, the mixing operation being supervised by the greenkeeper, the arsenated topdressing can then be loaded on a truck, carried to the green, and applied as usual by the men doing that phase of the topdressing job. This is the system which I instituted at the Pine Valley Golf Club, at Clementon, N.J., and which they have found entirely satisfactory with their type of labour.

At Pine Valley the arsenated topdressing is prepared in lots of one-half cubic yard each, the mixing all being done in a home-made square type churn, mounted on a shaft. This churn has a capacity of one and one-half cubic yards, but only a half cubic yard is handled at one mixing, first, because of the weight involved, and, second, because the machine mixes the small quantity much better as the mass has much more room to roll around in. The manager, Mr. Norman Mattice, knows just about how much area the half-yard of top-dressing will cover, depending on the season of the year, etc., and the quantity of arsenate of lead added to each one-half cubic yard of topdressing is accordingly altered at will.

I personally prefer this method of centralised mixing where the entire operation can be supervised by the greenkeeper or a responsible assistant. It may sound like a lot of extra work, but unless I am badly mistaken you will find, in the end, that it pays. Greenkeepers are naturally always looking for a short cut in doing big jobs, such as topdressing. There can be no objection to shorts cuts providing they are not too short.

Do not try to mix a few pounds of arsenate of lead with a large bulk of soil, by throwing the two together at one operation. It invariably results in an even mixture, with the bulk of the soil containing no arsenate. It is much better to mix the arsenate with a small bulk of soil, add some more soil and mix again, and continue thus until the entire bulk of soil incorporated. In any event the system to follow will depend entirely upon the individual greenkeeper and a little experience will soon indicate the best method for his particular conditions.

When beginning the operation of grub-proofing turf the amount of arsenate of lead to apply at one time per 1,000 square feet of turf will depend on the conditions confronting the greenkeeper. Whether to apply the 5 pounds all at once or in monthly instalments of one pound each depends entirely upon what the greenkeeper is up against as far as grubs, worms, or weeds are concerned. If grubs are working in the turf, if earthworms are annoying, or chickweed or crab-grass plentiful, then it will be advisable to apply the entire 5 pounds at one time. This amount will give any of the above pests a good stiff jolt.

If the greens are well under control and the pests are causing no undue annoyance, but the club has decided to inaugurate a grub-proofing campaign, the arsenate of lead can be applied at the rate of one pound per 1,000 square feet of turf for five successive topdressings. In other words, under conditions where the greens or tees are not threatened with disaster, there is no object in putting on 5 pounds all at once, because, even after the 5 pounds have been applied, either all at once or in instalments, it is necessary to apply one-half pound of arsenate per 1,000 square feet of turf with each subsequent topdressing in order to maintain the surface soil layer in a grub-proof condition. This half-pound dosage is based on a topdressing of one cubic yard to 5,000 square feet of turf, or, theoretically, a layer of soil one-sixteenth inch thick.

TOPDRESSING MUST CONTAIN COMPOUND.

Under the present top-dressing system of maintaining greens, the surface of the green is constantly being raised by the thin layer of soil deposited as a result of each individual topdressing. If these layers were not poisoned, the original 5 pounds of arsenate would be gradually buried by a composite layer of non-arsenated soil, and grub, worm, and weed control would no longer be secured.

This half-pound of arsenate can be mixed with the topdressing or mixed with a small quantity of soil or sand, and applied after or immediately before each topdressing, as described above. Some greenkeepers use arsenate in every other or every third topdressing, increasing the amount to one pound or one and one-half pounds, as the case may be. Whether this short-cut system results in the greatest degree of weed control is open to question, but, of course, from their angle and from the immediate point of view, it reduces the amount of labour involved.

TREAT APPROACHES ALSO.

There is a pronounced tendency on the part of most greenkeepers to stop short with all treatments of a chemical nature at the edge of the green. While entirely human, it is, nevertheless, a highly inadvisable system, because there are plenty of worms, grubs, and weeds in the grass just outside the area of the green proper, and they are constantly working their way into the green, with the result that even where a green is arsenated the outer portions will never be in first-class shape, because of the occasional worm or grub which works its way into the green, and does some damage before succumbing to the poison.

It is advisable, therefore, to arsenate the approach to the green, and a strip at least 10 feet wide immediately around the green, so that any grubs or worms outside this "barrier" area get a dose of the poison, and are killed before they ever succeed in getting into the green. Arsenate more frequently steep banks around greens and tees due to tendency to wash off.

Leach Debates Doubter of Arsenate of Lead.

B. R. LEACH'S series of articles in " GOLFDOM " on Grub Control have stirred up lively national interest. One of the responses to Mr. Leach's comes to us from an eastern source, under the heading, " Arsenate of Lead—A Cure-All or Kill-All for Greens?"

The one who questions the Leach conclusions writes:—

DOUBTS ARSENATE OF LEAD.

" Someone has recently spoken of arsenate of lead as the nearest thing to a 'cure-all' for turf troubles. Early experiments might seem to confirm this statement, but careful analysis, taking all factors into consideration, would indicate that in the end it is more apt to prove a ' kill-all,' and this applies to the turf, as well as to the grubs and bugs.

" There are several very important reasons why arsenate of lead would be dangerous to use on greens. In the first place the idea of poisoning the soil is fundamentally wrong. We cannot mix poison with our food without a harmful result, and likewise we should not mix a powerful poison with plant food. Arsenate of lead is made from arsenic and lead, and arsenic is known to be the most deadly poison to vegetation. Arsenate of lead is apparently insoluble in water, but the action of the elements, the chemicals in the soil, and the chemicals added to the soil in the form of fertilisers, will, in time, break down the arsenate of lead, and thus make it soluble and poisonous to the turf. This may be a slow process, but when it does take place it will do the turf a great deal more harm than good.

" Arsenate of lead will do away with the grubs, and there is no question about the advisability of killing and permanently eliminating grubs, because they do a great deal of damage, and serve no vital purpose in the soil. Unfortunately, however, arsenate of lead will also eliminate all other forms of life in the soil, and what is going to happen to the soil if all life in it is done away with permanently? There is only one answer, and that is that the soil itself will become dead. Bacteria, insects, and worms are needed in the soil for very definite purposes.

IMPORTANCE OF WORMS.

" Consider for a moment the important work that the worms perform in the soil. They are constantly burrowing through the soil in all directions, thus keeping the soil light and aerated so that the vegetation secures nourishment and grows easily. This lightening of the soil by the worms also causes better drainage.

" To be sure, they may be a nuisance on the greens during certain months, when they become too numerous and too active, but they are troublesome only for a few months, whereas they are performing a very necessary work the other months. When they become too numerous and troublesome, they can easily be removed by preparations known as worm eradicators, and without injuring the turf or poisoning the soil.

" Arsenate of lead, on the other hand, would not only kill the worms in the green, but, in fact, would permanently eliminate them, for worms could not exist in soil with this poison present. The result would be that, without worms, the soil would gradually pack down and become very hard, and would furnish very little nourishment to the turf. Proper drainage would not take place, and the green would soon become very sick. It might take three or four years before the grass would actually start to die, but the chances are that the use of arsenate of lead would necessitate completely rebuilding the greens within five years.

" Can you afford to take such chances with your greens? "

The answer made by Mr. Leach, referring to his extensive experiments with arsenate of lead, follows:—

LEACH'S REPLY.

" The above epistle is interesting, especially so because it puts in black and white the attitude as regards arsenate of lead in fine turf which I am satisfied exist in the subconscious minds of more than one individual at this time. However, the above remarks can be considered only of value as the personal opinion of the above writer, and not as a proof that arsenate of lead is a ' kill-all ' in fine turf. He presents no technical data or other substantiation of his stand on arsenate of lead.

" I realise that the very thought of adding arsenate of lead to soil outrages all the theories and sacred ideas of the old school, who consider such an action only as the violation of all so-called natural laws. I can remember, not many years ago, when the spraying of fruit and shade trees with arsenate of lead first came into vogue. All wise men designated it as a 'kill-all,' and tried to get legislatures to make such spraying illegal. It would kill the trees, and would kill the persons who did the spraying, etc., etc., ad infinitum, but please take note that they are still spraying trees with arsenate of lead, and will continue, no doubt, to do so until a better and easier method is found.

" All new methods, inventions, and innovations have to undergo this barrage of criticism, but if they are sound they emerge unscathed, and ultimately become an accepted, taken-for-granted part of our daily lives. So in the same way, I am entirely satisfied that the use of arsenate of lead in fine turf will be given a thorough trial by turf enthusiasts all over the world, and, if it is as sound a method as my six years of experimental work lead me to believe, it will take its proper place in the accepted system of turf maintenance.

"I do not intend to take the space here to refute the argument for arsenate of lead as a 'kill-all,' because the value of arsenate of lead in fine turf is now under discussion by myself in a series of articles appearing in 'Golfdom.' I would, however, suggest that the gentleman do a little bit of studying in elementary toxicology, plant physiology, and the chemistry, physics, and biology of soils. It would certainly help him to form a revision of opinion on the interaction of arsenate of lead, soil, and turf grasses.

SOIL ACTION.

"The action of soil upon arsenate of lead is not a slow or long-delayed process, in fact it begins at once, and continues for some time before a chemical equilibrium is set up between the soil and the arsenate. At the end of this time some of the arsenate of lead has broken down, forming a basic arsenate of lead, which is virtually insoluble in the soil solution, and is non-toxic to grubs, worms, and vegetation. Soluble arsenate, in the form of arsenate or arsenites is also formed, this being toxic to the majority of weeds, to grubs and worms, but non-toxic to the majority of fine turf grasses. The remainder of the arsenate of lead originally added to the soil stays in the soil chemically unchanged for long periods of time, years in fact, and does not influence plant growth one way or the other. It simply acts as a grub or worm poison. Therefore, if the grass is to die, or the soil to become barren, as a result of the application of arsenate of lead, it should take place with a few weeks, and not 5 years later, as the gentleman contends. I have turf at Riverton which has been arsenated for 6 years. It is still in first-class condition.

"If arsenate of lead did not break down in soil until 2, 3, or 5 years had passed, it would be valueless as a weed control agent, because it is the soluble arsenate so formed which acts in this capacity. If arsenate of lead were so stable that it did not break down in the soil, it would be valueless as a worm and grub poison, because it would then be too stable chemically to break down in the stomach of the worm or grub, and would fail to liberate the soluble arsenic which poisons.

"As far as earthworms are concerned you may have and welcome. I don't want them, neither do I want anything else on a golf green which interferes with true and sure putting."

How to Handle Fairways in Battle with Grubs.

By B. R. LEACH.

FAIRWAYS are a necessary evil as far as the average golf club is concerned. You cannot do without them in the game of golf, and yet even the cost of keeping them mowed is an important item in golf course maintenance. The attitude of green committee and club officials in general towards fairways, and especially their attitude on the spending of money for fairway betterment or insurance, was made very clear to me in the early days of the difficulty with the Japanese beetle grub. At that time the greens on several clubs in the vicinity of Riverton were looking pretty seedy as a result of the grubs present in the turf. I gathered from the remarks of certain passing female golfers that it was entirely impossible to putt on the blankety-blank greens, that the greenkeeper ought to be boiled in oil, and that the green-chairman was no gentleman. Not one word about the fairways, which, to put it mildly, were atrocious.

From what I have seen of the average golfer, it would appear that his thoughts are centred on the greens. If these are first-class, so that the ball stays put when lifted on to the green with a niblick, and the putting can be accomplished with the usual aplomb, you will get only an occasional and half-hearted growl about the condition of the fairways. But let the greens go bad, regardless of why they went bad, and the club membership hits the ceiling.

It is not surprising, therefore, that the officials of the clubs mentioned above begged me to concentrate on saving the greens. As the president of one club said, " Our greens are in bad shape as a result of this grub. Unless we can get them back into shape very shortly we will lose a large proportion of our members, and the club will be in a bad way financially."

Under the circumstances it is to be expected that the average green-committee will rarely wax enthusiastic on a proposal to spend much money on the fairways, while they will invariably endorse any plan which promises to improve the greens. Aside from the relative importance of greens and fairways in the minds of officials and players, there is another reason for the general apathy toward fairway improvement, and that is the item of expense. It doesn't cost so much, comparatively, to carry out a new scheme on the greens, but to do the same thing on the fairways runs into real money. There are two or three acres of greens on the average 18-hole course, as compared with 60 odd acres of fairway.

As a result, the fairways in the average golf course are more or less neglected, and most of them show it plainly. They are mowed religiously, and once in a great while some grass seed is scattered over them. As a matter of fact, you might as well throw grass seed over a cliff for all the good it does.

While, therefore, the use of arsenate of lead as a means of grubproofing greens is constantly on the increase in all sections of the country, I do not expect to see its use extended so rapidly in connection with fairways. If my experience around Philadephia is any criterion, I do not expect to see the average club grubproof its fairways until they are virtually ruined by grubs, and the bare soil in danger of being washed into the nearest creek. That this is poor business is obvious when you consider that the 250 pounds of arsenate of lead necessary to grubproof an acre of fariway can be bought for about $35, whereas, if you delay the grubproofing until the fairways are ruined, you will not only have to spend this $35 an acre, but also at least an equivalent amount for grass seed.

HAND-SPREADING IMPRACTICAL.

When applying arsenate of lead to the fairways, in view of the acreage involved, do not spread by hand; to do so will run up the labour cost to a prohibitive figure. It is much better to obtain the use of a first-class lime or fertiliser spreader, one that covers an appreciable strip for each trip across the fairway, and can be drawn by a tractor or horses. Unfortunately, many of these machines are built and designed to deposit the material upon the turf in drills running parallel and spaced a few inches apart. This may be entirely permissible with lime or fertiliser, but it will not prove satisfactory when spreading arsenate of lead. Therefore, when using a spreader of this type for fairway grubproofing, fix one or two baffle boards below the opening through which the material pours out from the box, arranging them on an angle so that the streams of arsenate hit them and are broken before they reach the ground, resulting in an even spread all over the turf. It is also a good plan to fasten some heavy burlap bags along the sides of the box, front and rear so as to prevent largely the tendency of the arsenate to blow about.

All these spreading machines have differently designed holding and feeding capacity, but all are capable of being regulated so as to spread dry, evenly screened material with a remarkable degree of accuracy if a little care is taken. In regulating and adjusting the machine it is best to gauge the amount spread over a long, narrow area of turf rather than a short, wide one, necessiating many turns, and it is best to do the regulating with plain screened soil or sand containing no arsenate of lead. Remember, in using these machines, that the wheels extend out beyond the box, and it is necessary to lap over the wheel marks somewhat so as to leave no untreated area.

After the arsenate has been distributed by machine, it is advisable to run a spike-toothed or diamond-pointed alfalfa harrow both ways across the turf so as to harrow in the arsenate of lead lightly without digging up the grass. Do this harrowing as soon as possible after the fairway is arsenated; there is less chance of surface soil-washing as a result of a heavy rain, with the consequent carrying of the arsenate into the low spots.

PREPARING ARSENATE FOR SPREADING.

Do not spread the arsenate over the fairways without first mixing it with dry filler, such as finely screened soil or sand—first, because 250 pounds of arsenate of lead is a relatively small bulk of material to be distributed evenly over an acres of ground, and second, because the material, a light fluffy powder, blows about at the slightest puff of wind. Hence, it will be found advisable to mix the arsenate with a quantity of dry soil or sand, first, to give added bulk so that the machine may function at its best, and secondly, because the arsenate will tend to cling to the particles of soil or sand, and when the mixture strikes the turf it will filter down through the blades of grass, and have decidedly less tendency to cling to them. The main idea when this job is completed is to have the arsenate *on the fairway*. The portion of the arsenate which blows over on the rough won't do a bit of good.

Filler for arsenate of lead, when the mixture is to be spread by machinery, should be dry; otherwise there will be endless trouble and uneven distribution due to clogging.

I am frequently asked regarding the feasibility of spraying the arsenate on to the greens and fairways, using a sprayer such as is employed for truck crops, and I understand that some greenkeepers are contemplating trying out this method. Personally, I do not consider the spraying of arsenate upon the turf an advisable procedure. Grubproofing dosages are relatively heavy, and the arsenate sprayed in this way will have a greater tendency to stick to the blades of grass; a pronounced burning may result.

In mixing dry soil or sand with arsenate of lead in preparation by machine, brains must be used to a certain extent, even though that unusual procedure may cause undue mental exhaustion and pain. Do not throw the sand or soil in a pyramidal heap, throw the arsenate on the top of the heap, and then make a few half-hearted stabs at the pile with a shovel. Proceed on the contrary, as follows:—Spread out the dry soil or sand on a smooth, hard-surfaced floor, making the layer a few inches thick, depending upon the amount of arsenate and soil you are mixing at one batch. Now spread the arsenate evenly over the layer of soil, and, using a scoop or flat shovel, dig into the composite layer of soil and lead arsenate, keeping the shovel in contact with the floor. Throw the shovelful in a heap at a convenient point on the floor, employing a twisting motion with the wrist so as to mix the arsenate and soil together as much as possible when the heterogeneous mass pours from the shovel. Take another shovelful in the same way and pour it *on top* of the first. Proceed and you will note that the pile assumes a cone shape and that each shovelful so added to the peak of the cone *runs down the sides of the cone*, resulting in a decided degree of mixing for the amount of labour expended. Continue until the layer on the floor has been entirely transferred to the pile. The mixing job is now half done. Now dig into the pile *from the bottom* with a shovel, scraping the floor, and throw the shovelful in a heap for the beginning of a new cone-shaped pile. Take each succeeding shovelful from the *bottom* of the old pile and throw it on the *top* of the new one. When you have built the second pile in this fashion, the soil and arsenate should be well mixed and in a condition suitable for the spreading machine. Incidentally, the individual doing the mixing will be in a general state of mental decrepitude.

WHEN TO GRUB FAIRWAYS.

If grubs are present in the fairways, and it appears that the latter are in danger of injury, apply the arsenate at once regardless of the season of the year, providing the ground is not frozen. If grubs are not present in the fairways but the latter are to be grub-proofed as an insurance against grub attack, the material is best applied early in June, since the great bulk of egg-laying by beetles occurs after this period, and the turf will then be in such a condition that the young grubs hatching from the eggs will be poisoned almost immediately by the arsenate in the soil.

MAINTAINING GRUBPROOF FAIRWAYS.

Two hundred and fifty pounds of arsenate of lead should maintain a fairway in a grubproof condition for two years, except possibly on slopes, where there is a tendency for the surface soil to wash. After the first year, keep an eye on the turf for earthworm casts. If these become sufficiently numerous to be noticeable, it is an indication that the grubproof condition of the turf is becoming weakened, and it is advisable to apply around 100 pounds of arsenate per acre, in order to maintain the grubproof condition.

It is only fair to the reader to state at this point that my experience with fairway grubproofing only covers a period of two years, whereas I have been working with greens for six years. That arsenate of lead will grubproof fairways is an established fact, but how long a given amount of the chemical per acre will maintain the grubproof condition I cannot say. This can only be determined by the continued observation for some time to come of fairways arsenated during the past year or two.

Many greenkeepers, when planning to grubproof fairways as above, will raise the question as to whether they can mix and apply fertilizers with the arsenate of lead, all in one operation. The answer depends entirely upon just what fertilisers you propose to use.

Rotted manure or mushroom soil, ammonium sulphate, synthetic urea, and such organic fertilisers as Milorganite, cottonseed meal, etc., are entirely permissible in this connection, but I do not advise the use of ammonium phosphate, acid phosphate, the chloride or sulphate of potash or sodium nitrate. The latter series of compounds react with arsenate of lead and tend to lower its grubproofing properties, although the vigour of the grass is not affected thereby.

Consider Organic Matter in Soil for Healthy Turf.

By AUSTIN J. CHENOWITH.

TO the man concerned in golf course construction and maintenance, it would be interesting to know how many of our golf organisations have had an uphill fight in acquiring first-class turf. This is because the topography and the price of golf land have been considered more important by purchasers than its natural ability to produce economically even fair golfing turf.

Hundreds of golf clubs in the United States are suffering to-day from such near-sighted selection. If we were to choose our professional golfer from the rural ranks because of his natural, physical beauty and ruggedness, and attempt within a few years to make him a fine example of a golfing mechanism, the cases would be almost parallel.

A farm physically fit to grow golf turf is rarely found on the market at an interesting price. If the property has been an intensive producer of any of the farm crops, it has been such because of scientific handling for many years with heavy expenditure for drainage and close attention to crop rotation. Each acre, because of the manure applied and the dead and decaying vegetation turned under, has become as "mellow" and friable as grandfather's garden.

For golfing purposes we select, for topographical reasons, the more rolling lands, from whose slopes, for ages past, any organic matter which might have been produced through the decay of vegetation has been washed into the valleys below, leaving behind a soil but little different in physical condition from its original form of finely powdered rock. We hardly realise we are trying to grow on such land probably the most intensive of crops, that of splendid fairways and putting greens. Every grain of this soil must be highly operative. We are satisfied only with a mat of turf so thick that it is next to impossible to separate the growing shoots and find the earth below.

The turf is, in itself, a tremendous feeder and user of moisture. Each green, of ordinary size, consumes daily an amount of feeding many times more than if the same area were devoted to the average farm crop, and often evaporates as high as a ton of water. Because of its congested growth, it is liable to every affliction that turf is heir to. Every square inch is in high speed at all times. There is no sign "keep off the grass" as would be given its weaker sister, the park or lawn.

The most cursory examination of a known fertile soil shows that it is, at all times, "mellow." Its soil particles have been separated by minute particles of organic matter which permanently keep them apart. If worked by plough or shovel, on the application of this pressure it immediately fractures into many very small units because of these separating particles.

On the contrary, in a soil deficient in organic matter, the soil particles cling together, and we have, upon turning, clods which are broken up with great difficulty. Should a soil, carrying the requisite amount of organic matter contract on drying, it will fracture evenly and at once become porous, due to the shrinkage in the organic matter. These fractures are fine enough to create a dust mulch, giving protection against too rapid evaporation of soil moistures at the surface.

Rain or sprinking, to replace lost moisture, will at once penetrate this soil, and, because of the ability of organic matter to retain moisture, it is held against the day when surface evaporation shall call for it, through capillarity, to replace the moisture lost, either through direct evaporation from the soil, or from plant life upon it.

A soil deficient in organic matter, and subject to such drying conditions, will, because of its tenacious character, fracture into several large cracks, which remain open and permit rapid loss of moisture. This loss is, unfortunately, largely from the soil lying below the roots of the plant life. Such soil has not been productive as farm land, yet frequently becomes the property on which we lavish our time and money in an effort to produce that most wonderful crop, good golfing turf.

Organic matter, then must provide a friable, porous soil, easily admitting large quantities of moisture and considerable air. This, however, is but a part of its value. All plant food material, before it is absorbed by the roots, must be prepared by the digestive soil bacteria, and made soluble in the soil moisture. It then can pass into the plant as the rootage takes moisture. These soil bacteria can best live, multiply, and operate as they should, in a medium such as well-decayed vegetable matter provides.

It matters but little how much food we have made available for the human body, if we have not the power of digestion and the assimilation of this food. So with our soils. It is very infrequent for a soil to be found which is actually deficient in any of the three primary feedings known to be necessary for plant life, unless such a soil is deficient in organic matter; rather, the most common finding is a lack of ability on the part of the soil to use the abundant feedings which are at hand, because of the failure of digestive power through a proper soil bacteria. Due to want of organic matter, an increase in the number of digestive organisms is not encouraged, insufficient feedings are provided, and a partial starvation of plant-life results. Very frequently, rather than additional plant food, cathartics are indicated, were it possible to administer such to the soil.

Organic matter suitable for golf turf production may mean any decayed vegetable matter, provided the decay is well advanced. Leaves, wood, manure, and even weeds, are satisfactory for construction and maintenance, if so handled as to allow them to break down after several years of exposure to moisture and plenty of air, so that their eventual fineness will not exceed one-tenth of an inch in diameter. This is important; unless these materials are in an advanced stage of decay, they will not have the power of increasing or decreasing their volume as moisture is added or removed, nor will they have the fineness to create the proper mechanical separation of soil particles. Any decayed vegetation, if allowed to gain this fineness, will have approximately the amount of feeding elements of a well-rotted horse-manure. In the compost pile, we merely create well-decomposed organic matter charged with the nitrifying organisms of the manure; the greater value lies in the degree of ultimate fineness of the organic matter which it may contain.

A fertile, porous bit of farm land must, of necessity, have no less than 40,000 pounds of organic matter in its top twelve inches of soil, per acre; this amount may be doubled to advantage in our fairways. In green-construction, because of the character of vegetation to be produced, the amount of organic matter used must be materially increased. This amount will vary, because of a natural organic content in the soil; but, whatever organic additions are made, it should be made, if possible, at the time of original construction by complete incorporation with the top twelve inches of soil.

The quantity must vary from ten to twenty-five tons per green, Well-decomposed organic matter has the power of absorbing 85 per cent. of its weight in water, and increasing its volume more than 100 per cent. when wet. When added to the green at the time of construction, it creates a reservoir of water in the green, which only protracted drought can exhaust.

Compost containing manure and sod in varying quantities, if well worked in, should contain organic matter in sufficient quantity to make a splendid top-dressing. It would, however, hardly contain sufficient organic matter for green construction, unless used as taken from the compost pile, and without further admixture of earth. A commercial humus is the common source of organic matter; its value depends upon its fineness, due to advanced decay and to its organic purity. A commercial humus, taken from a wet, undrained, uncultivated land, may be but partly decayed, and may throw off toxic conditions. It is rarely fine enough to provide proper porosity and friability, or "mellowness" of the soil.

If proper organic matter is not available, sand is frequently employed in golf soils to create porous conditions for late fall dressing; it is questionable whether it can take the place of organic matter in the preparation of beds, either for seeding or for planting by the vegetative method. If an equal mixture of sand and very fine organic matter be placed upon a hard clay soil as a top-dressing, it will be found, within a year, that the organic matter has penetrated the soil to a greater depth than the sand, due to its partial suspension in the water applied to the green, and the downward pull which gravity exerts upon this fine, thoroughly-wet, cellular matter. Sand cannot have the power of absorbing and retaining moisture, nor of contracting as moisture is removed. Porosity from the use of sand is limited, irregular and uncertain; and is due only to the contraction of particles of inorganic earth which the grains of sand may separate. It does not make a desirable home, or feeding, for our very necessary soil bacteria.

All too frequently, improper selection of soils for top-dressings is made. As a rule, a dark, rich-looking earth, taken from a low part of the golf property, is considered good enough for this purpose. Before such a selection is made, assure yourself of the organic content of this soil. A fair test may be made by drying a sample thoroughly and noting carefully its "mellowness," or the ease with which it may be crumbled by pressure in the hand. It must be observed that if there exists "mellowness," due to excess of sand, there still may be deficiency in organic matter.

In our virgin soils, Nature, aside from latent, fixed inorganic feedings, insisted that plant life should be self-sustaining through the life-cycle, death and decay of animal and vegetable matter. The tropics, where rapid decay, due to climatic conditions, offers the greatest possible amounts of organic matter for future fertility, give us a profuse development of vegetation. In our latitude, the higher lying slopes, hills and clay lands, before being cleared of vegetation, were extremely productive as virgin soils.

Clearing deprived these soils of proper organic matter for future decay, and further impoverished them by facilitating a wash of practically all organic matter to the lower valleys. These valleys became dark in colour, porous in texture, and of the greatest possible fertility, largely at the expense of the higher clay soils. These clay soils, unless scientifically replenished by the direct application of the organic matter, or the decayed vegetation resulting from the rotation of proper crops, rarely recover more than a trace of their former fertility.

Improper original green-construction has forced a great number of our older courses to rebuild their greens, through a series of top-dressings, with such mixtures of earth and organic matter as will more nearly imitate the best in modern green-construction. This is a slow and expensive process, but has proven the only means of correcting an unfortunate error in the original work. The golf organisations who, in their original construction work, properly cared for the organic content of their soils were very wise, and many, no doubt, acted more wisely than they knew.

How Soil Conditions and Worms Affect Greens.

By B. R. LEACH.

GREENKEEPERS, as a class, have no use for grubs, weeds, and brown-patch, but there are still a few members of the profession who have a more or less morbidly sympathetic attitude towards the lowly earthworm. Their attitude is based on the supposition that earthworms improve the soil, and cause fine turf to grow finer. The argument for earthworms in fine turf is typically presented in the following from one pen: " Consider for a moment the important work that earthworms perform in the soil. They are constantly burrowing through the soil in all directions, thus keeping the soil light and aerated, so that vegetation secures nourishment and grows easily. This lightening of the soil by the worms also causes better drainage."

All of which is interesting, but incorrect, as one knows who has studied the life-history and habits of earthworms. I always envy the non-professional writer or speaker on turf maintenance. Inasmuch as he has nothing to lose, he can say what he pleases without any fear of a comeback.

GREENKEEPER'S PLIGHT.

Greenkeeping is suffering from the machinations of men who think they know something about turf, and insist on writing about what they think they know. This vast output of literary effort is mainly characterised by a deplorable ignorance of technical and scientific fundamentals, and gives the studious greenkeeper a bad case of mental indigestion. The poor devil hardly knows who and what to believe, with the result that he doesn't believe anything or anybody.

Inasmuch as earthworms have been repeatedly observed and studied by such famous biologists as Charles Darwin (a complete account of their habits can be found in one of his books, or for that matter in the encyclopedias), there can be no good reason for any lack of sound information with regard to these pests. However, suppose we consider the earthworm from various angles in its relation to fine turf.

Inasmuch as earthworms are animals, they are chiefly concerned with the attainment of three desires—sufficient food, suitable shelter, and the perpetuation of their kind by reproduction. As regards the latter phase of their existence, it is enough to say that they lay eggs in capsules, 3 to 6 in each capsule, the latter the size of a small pea seed. These eggs hatch, and the young are fully grown in 4 to 5 months.

Earthworms are omniverous, meaning that they eat almost anything, including each other. In golf greens they feed on the partly-decayed blades of grass which fall in the path of the mower, humus matter in the soil, the eggs and larvæ of insects; but they apparently do not feed on living roots. They swallow large quantities of soil, merely to assist then in excavating their burrows. This is shown by the fact that earthworms living in poor soils almost devoid of humus nevertheless ingest much soil.

If you examine the turf early in the morning you may find little vertical tufts of dried grass blades sticking up, and if you look closely you will see that each of these tufts is projecting from the mouth of an earthworm burrow, and that the portion of the tuft in the burrow is much chewed and macerated. In gathering this food, the earthworm comes up so that almost its entire length is out of the burrow, but it remains firmly anchored to the burrow by means of its tail. Consequently, each worm forages as far from the mouth of its burrow as it can reach. As soon as it has exhausted the food supply within a radius around the mouth of its burrow equal to the length of its body, it makes another burrow at a distance as far out as it can reach, while still anchored to the old one by its tail.

The earthworm does its feeding and moving around on the surface generally after dark, keeping under cover during the day when birds and other enemies are around. In making its burrow, the earthworm goes almost straight down, pushing aside the soil particles or swallowing them. When complete, the burrow is a little wider than the thickness of the worm, and a little deeper than the earthworm's length. To prevent the walls of the burrow from crumbling in, the earthworm plasters them with a sort of glue-like cement, which it secretes for this purpose. Earthworms rarely go below plough-depth in the soil, except during the winter or when the soil becomes very dry during the growing season.

Having constructed its burrow, the earthworm proceeds to live a quiet, uneventful life, hunting its food at night, and coming up to void the contents of its lower intestine, which are commonly found scattered on the surface of fine turf, and are popularly known as worm casts.

Since earthworms burrow in the soil only to the extent of a narrow hole, a few inches deep, and not indiscriminately here, there, and everywhere through the soil, like maggots in a cheese, it is rather difficult to understand how they can be credited with aerating or lightening the soil. Furthermore, this idea of aerating or lightening the soil by such means as earthworms or spike-toothed rollers is fundamentally wrong. The aeration and drainage of the upper soil layer in a golf green needs no such artificial stimulation. In fact, such stimulation is harmful, to say the least. Aeration of the upper 3 or 4 inches of a green is entirely a problem of soil texture, proper subsoil and surface drainage, and topdressing with the correct soil mixture.

In spite of all that has been written on the subject of golf green construction and care from the soil standpoint, the average greenkeeper still seems to be labouring under a cloud of misunderstanding, with the result that fully one-half the work he does and much of the money he spends are wasted. At the start, let me say that the handling of a golf green is entirely and irrevocably different from the handling of any other crop that grows in soil, and yet this difference is very obvious if you stop and think for a minute.

The roots of closely-mowed fine turf grasses such as the bents are all within two or three inches of the surface. This means that the soil below this depth is of no importance whatever as far as it affects the grass or supplies food, always, of course, provided that this under soil is free from lime. Consequently, you can forget the soil below the three-inch depth except for one factor, and that is the factor of drainage. If your greens are naturally well-drained, well and good; otherwise, tile drains will be necessary, not only for the green, but for the surrounding ground. The top three inches of a golf green will never be up-to-snuff if the soil below is saturated with standing water. Such greens are suffering from chronic constipation, and you can't cure constipation by rubbing your scalp with hair tonic or bear's oil.

Consequently, when you spend all your money topdressing a waterlogged green, you are operating at the wrong end, and wasting your time and money. It seems platitudinous to harp on this questions of drainage in this day and age, but there are plenty of wet greens in this country. So much for subsoil drainage.

As far as surface drainage is concerned, you would think that anyone with half-a-head would know enough to avoid dished-in greens where areas or pockets of varying size hold the surface water after a rain, simply because there is not sufficient slope in at least one direction, so that the excess water can run off. And yet there are not many courses where you don't find some dished-in spots. Such spots are bad, first, because they get more water than they should, and are, therefore, generally soggy, and second, because this water from the surrounding higher portions of the green carries down soluble fertilisers, brown-patch control chemicals, and the like in excess. As this water in the low spots evaporates, this excess chemical stays in the low spots, and takes the punch out of the turf at that point.

Having provided for adequate subsoil and surface drainage, the latter by proper contouring, it remains only to get the upper three inches of soil in the proper physical condition, and to keep it so. What is the proper physical soil condition? The ideal physical soil condition for fine turf is embodied in what might be termed a medium loam soil. Such a soil contains sufficient clay or silt so that the soil has a maximum water-retaining capacity, but not so much clay or silt that it is sticky. It contains sufficient sand so that the soil is open and reasonably porous, and yet not so much that it dries out rapidly. Such a soil does not mould like putty if you squeeze it when wet, nor does it bake and crack when dry. You can make such a soil by mixing 20 per cent. clay or clay-loam, with 10 per cent. organic matter such as well-rotted manure, and 70 per cent. sand or loamy sand (all ingredients to be free of lime). The sand should be of a coarse nature, and you can increase the organic matter 5 per cent. more at the expense of the sand with impunity if you so desire.

As far as the organic matter is concerned, well-rotted manure is necessary, but half of the organic matter in the above mixture can well consist of imported peat moss, a product which the green-keeper will do well to get acquainted with. This material is not to be confused with peat out of our native bogs or the so-called humus or swamp muck, which was quite the rage some years ago. Peat moss is naturally rotted sphagnum moss which is taken out of old lake beds in certain of the middle European countries. It is finely granulated, and packed dry in 175-pound bales. In the first place this material is as acid as a California lemon or a 40-year-old spinster's tongue, which, together with its tremendous water-holding capacity, makes it an ideal material for use in the soil of a golf green. I predict a big future for this material in the golf-maintenance world.

If your golf course is located on a medium loam soil or you can obtain such soil for topdressing, count yourself lucky. If your course is located on heavy clay or on a sandy soil, it will be necessary to alter your upper 2 or 3 inches of soil on the greens so as to approximate the medium from soil type. If you are planting a green on heavy clay, contour the green as you wish it to appear finally, and then spread two inches of sand over the surface, add a light covering of organic matter, and then work the surface to a depth of *three inches*, no more, so that you drag up about three-quarters of an inch of the clay and mix it with the sand and organic matter.

Better still, spread the two inches of sand over the green, and then half-an-inch of clay on top, together with the organic matter, and work the mixture to a uniform condition and plant the seeds or stolons. If you are building a green on sandy soil, spread half-an-inch of clay or clay loam on the surface, together with the organic matter, and work it in to a depth of three inches, and plant the green. This system in either case will give a 20 per cent. clay content in the upper three inches, which is exactly what you want, and *no more*. If you don't want the surface to be sticky in wet weather and to bake and crack in dry weather, 20 per cent. clay is the limit in a golf green. A soil containing more than 20 per cent.

clay, say 30 per cent., is practically as sticky as one containing 90 per cent clay, although not many greenkeepers seem to be aware of this truth.

When it comes to top-dress, use the mixture of 20 per cent. clay loam, 10 or 15 per cent. organic matter, and the balance coarse sand. Never forget that the topdressing you are applying to-day is the golf green of to-morrow, and act accordingly. You can ruin a golf green in a season by topdressing with the wrong soil mixture, and spend the next two seasons in getting it back into shape. When greens are built and topdressed in this way, the aeration and drainage of the upper three inches will take care of itself, and I assure you that the earthworm will not be necessary. As a matter of fact, however, other things being equal, you will have plenty of earthworms in such a green, because when you provide these ideal soil conditions for the fine turf grasses you incidentally supply the very conditions most desired by earthworms. Hence they will flock to such greens, and control measures will be necessary. In my next article I shall have more to say about soil conditions as affecting the earthworm population, together with a discussion of methods of earthworm control in fine turf.

Proper Nitrate of Soda in Greenkeeping.

By D. T. CROAL.

Grand River Country Club, Kitchener, Ontario, Canada.

THE only way to be successful with fertilisers is to study the crop which is intended to be grown, and in the greenkeeper's case it is grass. To any plant there are three essential elements of food—nitrogen, phosphoric acid, and potash. These elements are all found naturally in good soil in varying amounts. The element nitrogen is the element that makes leaf in a plant, and, as the greenkeeper is striving to grow grass (leaves), nitrogen must, therefore, predominate in all fertiliser mixtures used.

There are different sources of nitrogen, and the most commonly used to-day on the golf course are sulphate of ammonia, nitrate of soda, blood meal, or tankage.

There has been a great deal of controversy about the use of nitrate of soda on putting greens, and most greenkeepers stick solely to sulphate of ammonia. This is due to ignorance and indiscriminate use of nitrate of soda, as nitrate certainly has its place on the putting green as well as sulphate of ammonia.

When using any fertiliser, the greenkeeper should always remember that it must be in solution before it is available. In the case of nitrogen it must not only be in solution, but must be in the nitrate form before it is available.

Nitrate of soda is already in the nitrate form, and as it is extremely soluble is available immediately it is applied.

SPRING TONIC.

In the early spring, therefore, a few pounds of nitrate of soda (about 5 pounds per 1,000 square feet) will start a green growing and act as a spring tonic.

Sulphate of ammonia and blood meal, on the other hand, are not available until natural nitrification of the soil has commenced. By that I mean the soil has to be warmed up to a certain temperature until the soil bacteria, which converts fertilisers into an available state for plant food, become active. Greenkeepers often make the remark that nitrate of soda will "burn" a green.

This is due to using too heavy an application, and not having the nitrate ground fine enough. It should always be pulverised very finely, and should always be washed in with the sprinkler. Small application should always be used, as better results are got with small applications at regular intervals.

I have introduced a system to our course, which was in a very impoverished state when I took it over, and I find I get good results.

As early as possible in the spring we apply nitrate of soda to the greens at the rate of 5 pounds per 1,000 square feet. As soon as the weather gets warm and natural nitrification has commenced we give the greens their first topdressing of sifted compost, sulphate of ammonia, and bone meal. This is well raked in and lightly rolled. After the green has become established again, and fit for play, we use nitrate of soda every two weeks till midsummer. The greens then get another dressing of sifted compost, sulphate of ammonia, and bone meal.

The nitrate of soda is then discontinued for the rest of the season. In the early fall the greens are again topdressed with compost mixture, and after the ground has frozen and the greens are out of play we give them a dressing of clean sharp sand of a fairly rough texture.

Fertilisers on a farm were never intended to take the place of stable manure, and on a golf course were never intended to take the place of compost, but to be used in conjunction.

The secret of greenkeeping to-day may be summed up in a few words—good compost, nitrogen, air, water.

Away with Worms.

Control Measures to Keep Greens Right for Putting.

By B. R. LEACH.

ON occasions when earthworms are unusually numerous on a particular golf course, or in an extensive section of the country, as was the case last year in the middle West, there is considerable conjecture among greenkeepers as to the reason for their undue numbers. In many cases the proponderance of the pest is laid to conditions which have absolutely no bearing on the question. It is quite generally believed among a certain proportion of the greenkeepers that organic fertilisers, such as cottonseed meal, tankage, etc., encourage the presence of earthworms and should be avoided for that reason. As already explained in "Golfdom," the earthworm feeds on partly decayed vegetable matter, such as dried blades of grass, etc., hence the presence of organic fertilisers would not directly stimulate the earthworm population. Such fertilisers, or for that matter, any chemical applied to turf, influences the earthworm population only as it improves the texture of the soil and renders it more friable and suitable for the earthworms' development.

Under normal conditions earthworms do not breed well or increase greatly in numbers during seasons of excessive rainfall, this being especially the case in heavy or poorly-drained soils, since this pest heartily dislikes excess water in the soil. Conversely it does not breed well or increase in numbers during dry seasons when the soil is dry and hard. At these times, earthworms usually are down in the soil at a depth where the soil is moist. Under the circumstances, a season of sufficient rainfall to maintain the soil in good, friable shape will, other things being equal, result in an abundance of earthworms in the fairways and approaches, with the consequent invasion of the greens from the surrounding turf.

The earthworm population usually increases rapidly on any piece of ground after it has been properly drained. On the other hand, greens built on very sandy soil soon begin to support a fair earthworm population as soon as the greens are topdressed with a mixture of soil and organic matter, especially if the soil used in the topdressing is heavier than the native sand. In both these cases the increase in worm population is due to the making of the soil more conducive to their well being; in the first instance by removing the excess soil water, and in the second instance by making the soil more capable of retaining sufficient soil moisture so that is does not dry out rapidly.

As stated in a previous article, the better the soil of your green is for the growth of turf, the greater will be the earthworm population. Under the circumstances artificial control measures are necessary to hold them in check on the choicer portions of the course, such as the greens and approaches.

EXTEND TREATMENT.

Before considering control measures it might be well to point out one fact which should always be borne in mind in connection with earthworm control, and that is the fact that no matter how often you treat a green for earthworms they will, nevertheless, be constantly creeping into the green from the surrounding turf, just outside the green proper. Consequently, when you confine your earthworm treatments to the green *only*, it is very improbable that your green will ever be entirely free from worm casts.

The system of stopping dead at the edge of the green when applying chemicals for earthworms is mighty poor business, and false economy. Extend the application of the chemical for at least 10 feet out beyond the edge of the green, 15 or 20 feet is even better.

Another ill-advised attitude of many greenkeepers is their snap judgment on a worm killer or a job of worm killing based entirely on how many worms come up to the soil surface and turn up their toes within a short time after the chemical is applied. If you will just retire to a quiet secluded corner for three minutes and do a little thinking you will realise that this method of judging a worm killer is abject bunk. When I am doing a job of worm eradication I don't give a damn if I never see a worm come up and croak. What I am interested in knowing is how many worm casts there will be on that green the second morning after I have applied the chemical. Dead men make no noise, and, believe me, dead worms make no casts, and the *absence* of worm casts is the surest indication that the treatment has been successful.

Another point to bear in mind if success is to be obtained with the use of such worm eradicators as bichloride of mercury or mowrah meal; as stated previously, the earthworm loathes dry soil and goes down to moist, cool soil when the top soil is dry and baked. Consequently, it is poor practice to treat soil in this condition for the control of worms, because the liquid has to penetrate the soil to too great a depth before it reaches the worms. Keep the soil of a green in a moist but not wet condition for a week before the application of the chemical, and the worms will be right up under the surface, so that the chemical can flood the earthworm burrows and give you a first-class control. Failure to observe this important point is the cause of many failures in earthworm control. The chemical will do the work if you give it half a chance. Furthermore, grass which has been dry for several days is in a weakened condition, and severe burning often results from treatment with bichloride under these conditions.

CONTROL MEASURES.

Mowrah Meal: This is a first-class earthworm killer, its principal value resting in the fact that it is pretty nearly foolproof, and can be applied with very little fear of burning the turf. It is, however, a very expensive method of worm control, inasmuch as the meal sells around 10 cents. a pound, and 35 to 40 pounds are necessary for a thousand square feet of turf. It is scattered dry over the green, and then watered thoroughly.

Bichloride of Mercury: As a worm killer this chemical is damned by some and praised by many. It is a first-class material if you use a little horse sense along with it. There are two methods of applying it to turf; first, in solution, by means of sprinkling cans, barrel sprinklers, etc., and second, dry mixed with sand. In the latter case the mixture of bichloride and sand is scattered over the green and watered in with a hose. Either method is good provided you know your stuff. In using the dry method, ten ounces of the bichloride is mixed with a sufficient bulk of sand to insure easy spreading, and applied to a thousand square feet of turf. After treating the green, water the green with a hose, but do not run the water on the green in one spot until it floods. Instead, water the green as a whole, going over and over it so that it soaks in without flooding or running-off into the low spots.

The second method of applying bichloride to turf consists in dissolving the chemical in water, and watering the green with the resulting solution. The accepted dosage consists of one ounce of bichloride to 30 gallons of water, the solution being applied at the rate of a quart to a square foot of turf. Bichloride does not dissolve readily in plain water, hence it should be prepared for use as follows: Dissolve eight ounces of ammonium chloride in one gallon of water, and then add eight ounces of the bichloride and stir thoroughly until everything is dissolved. One pint of this stock solution will contain one ounce of bichloride, and this is the amount to be added to 30 gallons of water for application to the green. Incidentally, some greenkeepers use one ounce to a barrel of water and secure good results, hence the dosage is more or less up to the operator.

DON'T FLOOD.

In applying the solution to the turf do not make the mistake of flooding the green with the solution, but rather apply it so it has a chance to soak in. Burning will result on many occasions when any portion of the green gets more that its share of the solution. Here is where low spots on the green, spots where there is little surface drainage, cause trouble in the application of worm eradicators. These spots get more than their share of the chemical, mainly due to the run-off from the higher portions of the green, and burning results in these dished-in depressions, no matter how much care is used in the application.

PROPERLY APPLYING.

Very few clubs have the apparatus for the job of properly applying bichloride in solution. The chemical is very hard on metal, hence it is poor business to use an expensive sprayer or proportioning machine. One enterprising firm, sensing this situation, manufactures a simple outfit for the application of bichloride solution to turf. It consists of a barrel mounted on wide-tyred steel wheels. A pipe lead from the bottom of the barrel to another pipe, which runs parallel to the ground, this latter pipe having holes every inch or so. This machine is simply pulled up and down the green, and the solution flows out through the pipe and is spread evenly over the turf. It is a very simple outfit, nothing to get out of order, and should last for years. It impresses me as the answer for those who wish to apply bichloride solution. This same firm also supplies the bichloride in solution, all ready to be mixed with water, a product which will often save the busy greenkeeper a lot of time and annoyance in procuring the ammonium chloride and in mixing the stock solution. Say what you will, it is often possible to be penny wise and pound foolish in buying the ingredients of an elaborate chemical mixture and then going to all the nerve-racking trouble of mixing them up with the limited equipment of the average tool shed. I have seen more than one man mix up bichloride and water in a tin bucket, and then lose it all when the bichloride ate a hole through the tin.

WHERE COMPOUNDER SERVES.

There are a few firms in the golf course supply business who manufacture first-class mixture of standard worm control chemicals, and put them up in shape all ready for use, with full directions on the can or glass bottle. I am strong for this sort of product, just as I am strong for any other form of *service* which saves me time and annoyance. In this respect I am only one of a crowd, hence there will always be a sale of any proprietary turf remedy which is scientifically correct in formula, and which is marketed in a form all ready for instant use.

There is plenty of room for improvement in the degree of cooperation between the so-called technical turf expert and the manufacture of turf maintenance supplies. The former should quit knocking the latter, while the latter should pay more attention to the findings of the former.

Arsenate of Lead.—This chemical is rapidly coming into use for the control of earthworms in fine turf. Inasmuch as I am the discoverer of this chemical as a grub, worm, and weed control agent, I will not go so far as to say that it is the best means of controlling earthworms. I will say, however, that those who have used the arsenate of lead method are not, as a rule, forsaking it for other methods.

The chemical owes its worm controlling properties to the fact that earthworms are constantly swallowing soil, and when the latter is impregnated with the chemical the earthworms are killed. This means that a golf green which has been grub-proofed with arsenate of lead, according to the methods described in several of my articles, which have appeared lately in "Golfdom," will rarely have a worm cast on them, and especially so if the area immediately around the green proper has also been grubproofed.

Any earthworm which evades a grubproofed green is automatically killed as soon as it begins to take in a little soil during the course of its burrowing operations. There is nothing spectacular about the use of arsenate of lead as a worm control agent. It doesn't bring the worms up to the surface when you apply it, but, nevertheless, it is a sure way of keeping the turf free from objectionable worm casts.

In the last analysis the greenkeeper can make his own choice of worm control methods. Bichloride or Mowrah meal will clean up what worms are present in the turf, but they won't prevent reinfestation, hence they must be applied at frequent intervals in order to keep down the worm population. Arsenate of lead, on the other hand, is always there ready for business, the moment an earthworm pokes its head on the green.

A CORRECTION.

Since the publication of my article dealing with the control of earthworms in turf, it has been drawn to my attention that the dosages of Mowrah meal and bichloride of mercury as recommended in that article are incorrect.

Further investigations into the matter would indicate that the dosages of these two materials as recommended in the article are not so much incorrect as they are out of date.

The present recommendations for bichloride of mercury for worm control, when applied in the liquid form, consist of two to three ounces of the bichloride dissolved in 50 gallons of water, and applied to 1,000 square feet of turf. When applied in the dry form, two to three ounces of the chemical are mixed with the sand or soil, and applied evenly to 1,000 square feet of turf.

As regards Mowrah meal, the present dosage consists of 15 to 20 pounds of the meal applied to 1,000 square feet of turf, which, in view of the present low prices of this material, is far from being expensive as a worm control agent.

Another fact which I neglected to mention in connection with the use of bichloride; avoid the use of the material during the hot season. It is better to do the job of worm eradication with this compound in the spring or fall.

Fertilisers—Something about their Character and Use.

By O. J. NOER.

THE intelligent use of fertilisers promotes the growth of good turf on greens and fairways. Successful turf culture also depends upon an ample supply of water and light, favourable soil conditions, selection of varieties of grasses adapted to local climatic conditions, and protection of the turf from injury. When these are favourable, plant feeding becomes the prime factor in turf culture.

Ten different chemical elements are required by plants to make complete growth, and when any one or more is lacking, or deficient, normal growth is not attained. Turf culture is concerned with only three of the ten elements, namely, nitrogen, phosphorus, and potassium. These are often referred to as ammonia, phosphoric acid, and potash. The other seven elements are generally sufficiently abundant to supply plant needs.

The solid substance of the soil is made up of minerals derived from the disintegration of rocks and organic matter, or humus, resulting from the decay of plant and animal residues. Most of the soil nitrogen is stored in the dark-coloured humus, hence dark-coloured soils usually contains more nitrogen than light-coloured soils. Humus also contains some phosphoric acid and potash, but the main supply of these elements is derived from the mineral constituents of the soil. Phosphoric acid and potash are most abundant in the small soil particles, silt and clay.

In general, peat and muck soils are high in nitrogen, but often low in phosphoric acid, and particularly potash. Sands are often low in all three elements, especially nitrogen. Heavy soils, while they usually contain abundant supplies of potash, may be low in phosphoric acid, and are usually deficient in nitrogen, especially when turf grasses are grown continuously.

Nitrogen is the most essential element in turf culture, due to its effect upon vegetative growth. Within certain limits, the amount of growth is proportional to the amount of nitrogen available. The dark green colour associated with rapidly growing foliage is largely the result of an abundance of nitrogen. Hence, the need for nitrogen can be judged by the rate of growth and depth of colour of foliage.

Phosphoric acid affects seed formation, which is of little interest in turf culture, but it also encourages root formation and development. The young grass seedling must get its food from the soil very early, because the young seed contains very little stored food, hence, the presence of ample phosphoric acid is of primary importance in promoting establishment of young grass, Potash aids in the formation of a class of substances called carbohydrates (sugar, starch, and cellulose). The first two are sources of energy, while cellulose is the substance which makes up the structural portion of the plant.

The growth of clover is stimulated by phosphoric acid and potash, so their use beyond the absolute requirements of the turf grasses is generally discouraged.

NITROGEN OCCURRENCE.

Nitrogen occurs in different forms which may be classified into the three following groups:—

1. Organic nitrogen is derived from animal and plant residues. The principal sources are manure, cotton-seed meal, dried blood, animal tankage, fish scrap, and milorganite. Most organic nitrogen is insoluble in water, and is not available to the plant until broken down into other forms.
2. Ammonia nitrogen is the form of nitrogen in ammonium sulphate and ammonium phosphate. Both are water soluble, and, while many plants cannot assimilate ammonia as such, nitrogen, in this form, is readily available.
3. Nitrate nitrogen is the form of nitrogen in nitrate of soda. All nitrates are water soluble, and nitrogen in this form is preferred by most plants.

While plants prefer nitrate nitrogen other forms of nitrogen are converted to nitrates by the bacteria of the soil. During decay, organic nitrogen is first converted to ammonia, and the ammonia is then changed to nitrate nitrogen. Soil bacteria can and do convert the ammonia nitrogen of ammonium sulphate and phosphate into nitrate nitrogen. Since decay is necessary, organic nitrogen is usually more slowly available than either ammonia or nitrate nitrogen.

Soluble nitrogen is easily lost from the soil by leaching, and on greens the loss may be serious, due to frequent watering. Organic nitrogen is not so easily lost because the nitrogen must be converted into soluble forms, by soil bacteria, before leaching can take place. By making frequent light applications of soluble nitrogen fertilisers, the danger of loss is reduced. A longer feeding of turf can be obtained by using a small amount of ammonium sulphate or phosphate, together with an organic material. The immediate needs of the turf are satisfied by the ammonium sulphate or phosphate, and the later needs by a gradual conversion of the organic nitrogen into available form as needed by the plant.

PHOSPHORIC ACID SOURCES.

Bone meal, ammonium phosphate and acid phosphate, are the principal sources of phosphoric acid, and, of these, bone meal contains the least readily available phosphoric acid. The water soluble phosphoric acid of ammonium phosphate and acid phosphate is not lost from the soil by leaching, because insoluble compounds are formed in the soil.

In non-acid soils lime phosphate is formed, but in acid soils iron phosphate is produced, because acid soils are deficient in lime. Iron phosphate is less readily available than lime phosphate, so acid soils often require applications of phosphoric acid. Greens, fertilised continuously with acid producing nitrogenous fertilisers, may eventually require limited applications of phosphoric acid.

POTASH SOURCES.

There are two sources of potash, muriate and sulphate of potash, each containing about 50 per cent. potash. Both are water soluble, and, hence, readily available for plant use. Potash does not leach from the soil, because any soluble potash applied in fertilisers is absorbed and retained by the finer constituents of the soil.

An understanding of the mechanism whereby plants obtain phosphoric acid and potash is important in the intelligent use of these materials. The insoluble phosphate and potash compounds formed when these materials are applied to the soil in fertilisers are not directly available to the plant. Plant roots can only absorb materials dissolved in the soil water. But there is always a little phosphoric acid and potash dissolved in the soil water, and as the turf removes these materials the supply is replenished by solution of some of the insoluble phosphate or potash. When the turf makes heavy demands, solution must take place rapidly, or the plant suffers. Thus, the rate of solution determines whether the turf can satisfy its requirements.

Soluble prosphoric acid and potash, when applied to the soil, are fixed in a condition which permits rapid solution whenever the plant makes heavy demands.

Since phosphate and potash fertilisers are quickly fixed in the soil, best results are usually obtained when they are worked down into the region of the soil where maximum root development occurs. Uniform distribution is also important, because very little lateral movement of soil water takes place. Soils are so often low in phosphoric acid that it is well to apply phosphates to new fairways prior to seeding. At this time the phosphate can be worked down into the soil by discing, and, since there is no danger of loss by leaching, the added phosphoric acid provides for plant requirements over an extended period.

SOIL REACTION.

In addition to supply plant food, fertilisers affect the soil reaction, and may tend to make the soil either more or less acid. Since an acid reaction discourages the growth of clover and weeds, fertilisers which promote acidity are preferred. Nitrogenous fertilisers affect the soil differently; nitrate of soda decreases soil acidity, ammonium sulphate and ammonium phosphate increase acidity, while dried blood and activated sludge have but little effect on the reaction.

When nitrate of soda is applied to the soil, the nitrogen is used by the plant, and the soda is left in a form capable of neutralising any acid already existing in the soil.

While the plant also uses the nitrogen of ammonium sulphate and phosphate, the residue left in the soil is acid in character. Bone meal tends to decrease acidity because of the lime contained in the mineral portion. Acid phosphate also decreases the acidity of acid soils. In the formation of iron phosphate, previously referred to, the small amount of lime contained in the acid phosphate is released in a form capable of neutralising the acid in the soil. Acid phosphate has less effect on soil reaction than bone meal, because it contains less lime. Potassium fertilisers increase soluble soil acidity. This is because the residue left, after potassium is taken up by the clay, has acid properties.

Acid producing fertilisers are now generally used on greens, but some factors connected with their use are often overlooked. Heavy soils in particular possess a remarkable power of resistance to change of reaction, and, as a consequence, repeated applications are necessary to produce the desired results. Sandy soils are more easily changed. The soil or sand used in topdressing mixtures often contains sufficient lime carbonate to easily overcome the acid producing power of any fertiliser used. Manure contains considerable lime, and when used in large quantities in topdressing mixtures, tends to decrease soil acidity.

Battle with June Beetle—Foe of Fine Turf.

By B. R. LEACH.

IN the territory lying south of a line drawn from New York City due west to the Mississippi River, the June beetle is the one insect pest which has a pronounced tendency to cause greyheadedness among the greenkeeping fraternity. This area is the home of the June beetle, and it causes as much damage to golf courses in the south-east as any other two turf pests combined. Inasmuch as the annual period of turf injury by this grub is rapidly approaching, and, but little margin of time remains for the application of remedial measures, it would seem advisable at this time to discuss the habits and life-history of the insect, turf conditions which affect it favourably and adversely, and lastly, but not least, methods of control in fine turf.

The adult beetle measures a little less than an inch in length, and approximately one-half inch in width. The head of the beetle is metallic green, the back a velvety green, and the under portion of the body a brownish green. It makes its appearance above ground about the first week of July in the latitude of Louisville, Ky., and as early as the last week of June at Columbia, S.C. South of these locations their appearance is proportionately earlier, and towards the North the date of emergence of the adult is proportionately later.

Shortly after emergence the beetles mate, and the females begin laying eggs in the soil, these hatching ordinarily in two or three weeks. The young grubs grow rapidly, and continue to feed until cold weather sets in, by which time they are at least two-thirds grown. During the cold portion of the year they remain dormant at the bottom of their burrows, which may be as much as two feet below the surface, although, in the South, they may come up to feed during the warm spells in the winter. Active feeding begins again in the spring, and continues for a short time, at the end of which the grub undergoes certain changes and transforms to a beetle.

GRUB IS GREEDY.

When the grub of the June beetle hatches from the egg it feeds on the organic matter of the soil in the immediate vicinity for a short time, and soon comes up near the surface. Here it constructs a small burrow, which gradually becomes deeper as the grub increases in size and strength. The purpose of this burrow is undoubtedly that of securing protection from birds and other enemies which loiter on the surface of the soil during the day time, for during that period of the 24 hours the grub usually stays at the bottom of the burrow, and comes up at night to feed and to void the contents of its lower intestine.

Contrary to the opinion of many, the grub of the June beetle does not feed on grass roots. Rather, it feeds on the organic matter of the soil in which the grass roots are growing, and injury to the turf is caused by the burrowing and tunnelling which the grub continually does in its pursuit of food. This tunnelling and especially the tunnelling of the young grub just under the surface of the soil, is its one weak trait in an otherwise pretty sound scheme of existence, and the trait which I have capitalised in using arsenate of lead as a measure for its control. This phase of the problem will be discussed at greater length under the discussion of control measures.

Inasmuch as the food of the grub of the June beetle consists of organic matter, with a special fondness for rotted manure, it follows that the beetle, in laying its eggs, is naturally drawn to soil situations where organic matter of this nature is present in the soil in ample amounts. Greenkeepers in the South, and especially the seasoned members of the brotherhood, are fully aware that the heavy manuring of the turf of a golf course invariably results in the subsequent heavy infestation of the manured turf by the June beetle. Consequently, in past years they have been between the devil and the deep blue sea. If they manured the turf they had good grass, and it stayed good until the June beetle got busy and ruined it. If they didn't manure the turf the grass was poor.

A typical experience with the June beetle, and all the misery it is capable of causing, occurred at the Pine Valley Golf Club some years ago. This course, located on the edge of the pine barrens in New Jersey, is built on an almost pure sand. When the course was built, and for some time after, large amounts of manure were used in order to enrich the weak, sandy soil, the motive, of course, being a good one. Everything went well for a year or two, and then the June beetle began to become decidedly numerous until it ultimately almost ruined the course. In other words, here was a combination of circumstances and conditions which, through nobody's fault in particular, gave the June beetle an ideal set of soil conditions in which to increase and multiply, for there is no condition more desired by this grub than a light, well-drained soil, well supplied with organic matter and particularly if the latter is of an animal origin.

GRUB BAFFLED THEM.

Some cryptic comments on the situation at Pine Valley during those years, from the pen of Mr. Alan Wilson, can be found in some of the back numbers of the Bulletin of the Green Section (1921 or 1922). They tried all known methods of controlling the grub, but with little success. They simply had to stand by, abstain from the use of animal manure, and wait for the grub infestation to work itself out. This gradually took place as the organic contents of the soil burned itself out. For a year or two, prior to 1928, the grub has not been seriously bad at Pine Valley, although there were plenty of them present on the course. In 1928 they began the use of arsenate of lead on the greens and fairways for the control of both the June and Japanese beetles, and if this treatment is maintained it is very improbable that grubs will ever again be a problem with them. This, in spite of the fact that they are again using adequate amounts of manure for the topdressing of greens and fairways. In the absence of the arsenate of lead method of control of the June beetle grub it would have been interesting to see how long a course such as Pine Valley, built on nothing but sand, could have endured without the liberal employment of animal manure.

As stated above, the grub of the June beetle is not a feeder on the roots of turf. The injury is caused, first by the tunnelling of the grub just under the surface of the soil, during which operation it loosens the individual grass plants of the shallow-rooted, closely-cropped turf, causing the ground to become unduly loose and porous to such an extent that the upper soil layer has a pronounced tendency to dry out, thereby killing the turf. The second type of injury results from the mounds of soil which they are constantly throwing up at the mouths of their burrows. These mounds may be best described as comparable to greatly enlarged anthills. In addition to roughing up the turf, beyond almost all hope of redemption, these mounds smother the grass immediately beneath, unless they are promtly levelled.

There have been many suggestions for the control of the June beetle advanced from time to time, but they have never really furnished an answer, at least from the standpoint of golf course maintenance. It is all very well to advise the discontinuing of applications of manure to turf in those sections of the country where the June beetle is present in large numbers, but this is not really an answer, because manure is necessary for the growth of fine turf grasses.

The injection of liquid carbon disulphide into the mouths of the burrows is frequently found recommended for the June beetle, and it is effective within the limitations imposed by squirting the liquid into the thousands of burrows present when there is a real infestation of the June beetle to contend with. Furthermore, the carbon disulphide has a tendency to burn the turf in the immediate vicinity of the spot where it is injected into the soil.

Many clubs in the south have made a practice of hiring the caddies and other individuals to collect the beetles and grubs on the course during the June beetle season in an effort to decrease the injury to turf. For several reasons it is rare for value to be received for the money expended in a campaign of this sort. The vast majority of the adult June beetles collected on the course during the daytime are *males*, and there is nothing gained by collecting them because they have not as yet learned to lay eggs. The female beetles hug the ground as soon as the sun rises or shortly after, and go about their business of egg-laying. Gathering grubs is also of rather doubtful value as far as ensuring smooth, unpitted turf is concerned, because a considerable bulk of the damage to the turf is already accomplished before the grubs are large eonugh and conspicuous enough to be readily detected and captured. Furthermore, no matter how assiduous a collector of grubs you may be you never get more than a certain proportion of them in a given area of turf.

ARSENATE OF LEAD FOR JUNE BEETLE CONTROL.

When I was carrying out the experimental work on the control of the Japanese beetle grub by means of experimental plats at the Riverton (N.J) Country Club, it was interesting to watch what happened when a June beetle grub wandered into the plats treated with arsenate of lead. It never made but one burrow, and one mound, when it hit the arsenated soil. The next day, if one explored the burrow the grub would be found at the bottom either sick and flabby, or in the first stages of decomposition. In other words, in making its burrow it got a dose of the poison and succumbed. Please bear in mind that these were large, well-grown grubs, which are much more difficult to poison than are newly-hatched grubs.

With most clubs in the June beetle area the maintaining of the greens free from injury by this pest is all that is desired, and only the ultra de luxe golf clubs are desirous of protecting both the greens and fairways. Under the circumstances, the method of grubproofing turf, as described in my previous articles, should be followed for the control of this grub, namely, five pounds of arsenate of lead per 1,000 square feet of turf, the powder to be mixed with a quantity of soil or sand scattered over the turf. This dosage has given adequate control of the June beetle at the Riverton Club, where in past years it frequently played hob with several of the greens each year.

The soil on this course is of a sandy nature, and the arsenate of lead penetrates into the soil for a short distance. In soils of a clay nature it may prove advisable to use 10 pounds of arsenate of lead per 1,000 square feet of turf, applying the poison in two separate applications of five pounds each, about a month apart. This will, undoubtedly, give the greater tendency for the arsenate to work into the more dense clay soil, and ensure a better mixture in the upper half-inch or inch soil layer. If you are not already applying arsenate of lead with the topdressing as a regular part of the treatment of the greens, the arsenate should be applied, in the case of the 5 pound dose, as soon as the June beetle's adults are observed flying about the course. If you plan to use the 10 pound dosage apply the first five pounds a month before the appearance of the beetles, as near as you can estimate from the experience of former years, and the second five pounds as soon as the beetles make their appearance. The above dosage applies also to fairways in case you wish to render them proof against the ravages of this grub.

In arsenating greens for the control of this grub, it is absolutely useless to limit the arsenating to the green proper, since the grubs will be plentiful in the soil just outside the closely-mown green, and as soon as they attain any size they will begin to migrate into the green, and throw up mounds until they begin to get the poison, and these mounds are enough to ruin the green for the balance of the season.

In order to protect the green from all danger of tunnelling and burrowing, it is absolutely necessary, to grubproof, at least a distance of 25 feet, while 35 and even 50 feet is better. Remember that these grubs are capable of travelling relatively long distances on their backs, and the idea is to have sufficient poisoned soil around the green so that a grub travelling toward the green is poisoned long before it ever attains its goal. If there are any steep banks around the greens, watch them closely, as the arsenate has a tendency to wash off these steep slopes, and more frequent applications of the arsenate are necessary on these slopes.

Doing Away with Weeds.

By B. R. LEACH.

THE spectacle of five or ten boys or men reclining in more or less graceful attitudes at spaced intervals over the topography of a golf green, each more or less assiduously engaged in digging out the festive crab grass with a dull and rusty knife, is still altogether too common-place in this age of efficiency. When a green gets into a condition where wholesale hand weeding must be resorted to it is simply another instance of locking the stable after the horse is stolen. The greenkeeper is a busy man, and during the season of maximum weed growth he is pushed to the limit to maintain the course in fair playing condition for the period of yearly maximum play which corresponds usually with this period of heavy weed growth. Under the circumstances the greenkeeper cannot be entirely blamed for letting the weeding go until rank growth reaches a stage where there is no fun in it. When a green, heavy in weed growth, is finally weeded, it has all the aspects of a singed cat; thin turf, spotted and pitted with holes left by the knife, rough and uneven, and entirely unsuited for the de luxe putting of the effete, present day golfer. Then follows a distracting period of topdressing, fertilising, etc., with the object of nursing the green back into shape, all of this taking place at a period of the year when the growth of the grass is naturally slowing down. Year after year the struggle continues. It is no wonder that half the time the greens are in poor playing condition.

That the above system of hand-weeding is out of date, and not in keeping with the present day system of doing things in a so-called scientific manner, goes without saying, but some years will yet elapse before the system of wholesale hand-weeding will give way to the cheaper and more efficient system of weed control by the use of certain chemicals, notably ammonium sulphate and arsenate of lead.

AMMONIUM SULPHATE'S VIRTUES.

Ammonium sulphate has been in extensive use for several years as a fertiliser and weed control agent in fine turf. It is a valuable chemical, and has its place in the scheme of things. Its fertilising value has never been seriously questioned, but its weed controlling value has been the subject of much discussion, pro and con. and not by any means all con. This condition of affairs is no one's fault in particular, but is due to a combination of circumstances of a rather complex nature, which I shall try to explain at this time.

When ammonium sulphate was first advanced as a weed control agent, it was hailed with a fair measure of acclaim by the more progressive fraternity of turf enthusiasts. They proceeded to give it a thorough try out. Some of these experimenters were hotblooded, and the compound was altogether too slow in its action to satisfy them. Consequently, we have passed through a period of years in which ammonium sulphate has been the target for all the gibing shafts of many who think they know a lot about turf and in reality don't know much. Some of these boys are still knocking. In extenuation of this school of thought as regards ammonium sulphate, I will say that in my opinion, just a little bit too much has been claimed for this compound in the past than can be entirely justified by subsequent experience.

On the other hand, the more conservative of the amateur experimenters with ammonium sulphate continued to test it and say little or nothing during the extended process. As a result of several years of this testing, they have arrived at certain conclusions, sound, conservative, and based on solid fact. Hark, for instance, to the written opinions of Joseph Valentine, greenkeeper of the Merion Cricket Club, Haverford, Pa. I have known Mr. Valentine for a good many years, and take this opportunity of advising all and sundry that, in the vulgar parlance of the day, he knows his onions.

VALENTINE'S EXPERIENCE.

In the current issue of the "Bulletin of the Green Section," page 122, he writes as follows:—"Sixteen years ago the fairways of the east course of the Merion Cricket Club were seeded with a mixture of Kentucky blue grass and South German mixed bent. The following year the fairways of the west course were seeded with the same mixture. Our fairway fertilising programme then included the application of bone meal, mushroom soil, nitrate of soda, and some limestone, especially where we believed the soil to be acid. In 1920, eight years ago, our fairways were covered with crab grass, goose grass, and clover. In the latter year we discontinued the use of nitrate of soda, and in its place began the use of sulphate of ammonia. The weeds in the fairways have since been reduced about 80 per cent, and the clover almost 90 per cent. In fact, there is practically no crab grass in our fairways at this time. We expect to have all the weeds and clover completely eradicated within the next few years.

"This year, for the first time, we have also used activated sludge on our fairways, mixed with arsenate of lead at the rate of 500 pounds of the sludge and 40 pounds of arsenate of lead per acre. The arsenate of lead is used as a grub control, and also to eliminate chickweed, which has started to appear prominently on some of our fairways. Last year we used arsenate of lead on our putting greens, applied mixed in topdressing, at the rate of two pounds per 1,000 square feet of surface. We did not have to remove a single plug of chickweel from the greens, as had been necessary previous years, and very little of the so-called fall grass (I presume he refers to *Poa annua*) appeared on the greens."

Mr. Valentine then goes on to say that three applications of ammonium sulphate are applied annually, each consisting of 150 pounds per acre, the first in early spring, the second in July, and the third the middle of September.

Suppose we take the time to analy e the two paragraphs above as written by Mr. Valentine. By doing so I believe it will be possible to readily explain the course of events at the Merion Club, and also to show the reasons for the changes in the fairway turf as they occurred.

SOIL NATURE CHANGES.

Prior to 1920 they used bone meal and nitrate of soda, and some limestone, so that while in all probability the soil was neutral or slightly acid at the inception of this fertiliser programme, they nevertheless gradually changed the nature of the soil, causing t to become alkaline. This programme could result in only one thing if continued long enough; it simply made the soil less suitable for the fine turf grasses, and more desirable for weeds, hence the weeds flourished. In 1920 they faced about, discontinued the use of nitrate of soda and other fertilisers with a tendency to make the soil alkaline, and began the use of ammonium sulphate which has exactly the opposite effect on soil. They thereby began the long, uphill fight to change the nature of the soil from the alkaline to the acid. Believe me when I say that this is some job with the chemicals we have available for this purpose at the present time. As the ammonium sulphate was applied year after year, the lime gradually worked out of the soil, and the latter gradually took on an acid reaction. In this operation they were aided by the fact that the soil was in all probability of a naturally acid nature to begin with, and no watering with lime-impregnated water was resorted to. As a result of eight years of this continued treatment, the weed growth has been appreciably reduced, the clover almost eliminated, and the grass is going strong.

It is fairly obvious that there is nothing of a quick-acting or spectacular nature in the results obtained from the use of ammonium sulphate as a weed control agent. The weeds do not disappear overnight in fact, it is not a question of days or weeks in obtaining weed control with this compound, but rather a question of consecutive years of consistent and persistent treatment, hence the impatience of those who demand quick results.

The experience of Mr. Valentine with this chemical has been reasonably satisfactory, because his course is located in a section of country where the soil is naturally slightly on the acid side. Under these soil conditions every bit of ammonium sulphate applied gets in its good work, and gradually but steadily increases the acidity of the soil, although in t..is case it required a longer period of time due to the previous applications of limestone, bone meal, etc.

ALKALINE CONDITION.

Let us suppose, on the other hand, that your course is located on naturally alkaline soil, high in lime content, such as is prevalent in large areas of the middle west, and where in all probability every drop of water used for artificial watering is impregnated with lime Under these conditions every bit of ammonium sulphate is just as good a course of nitrogen as any other fertiliser, but it is my candid opinion you will never be able to safely apply enough ammonium sulphate in ten years of consistent treatment to make that soil acid, and thereby obtain any degree of weed control. The lime content of the soil and water is too big a handicap for the limited amount of ammonium sulphate which can be applied annually with safety.

On many courses all the expected weed control from the use of ammonium sulphate is counteracted by the soil, sand, etc., used in topdressing, any or all of which may be barely on the acid side or even alkaline in nature, so that the ammonium sulphate in the limited quantities applied is entirely incapable of counteracting the alkalinity of the relatively huge bulk of soil annually applied.

To sum up the situation: if the soil of your golf course is not naturally alkaline, and you take care that all materials, such as soil, sand, fertilisers, etc., applied to the turf are not alkaline, then ammonium sulphate will return dividends as a weed control agent apart from its fertilising value. If your soil is naturally not alkaline, but has been artificially rendered so by the use of lime or alkaline fertilisers, then the use of ammonium sulphate will change this soil condition and pay dividends, *but* it will be a long drawn-out business, a matter of years and not months. If your soil is naturally alkaline, and your water supply is impregnated with lime, then ammonium sulphate is one of your best fertilisers as a sourse of nitrogen, but you might as well forget it as far as weed control is concerned.

To become more specific as regards the action of ammonium sulphate on the more common weeds infesting golf courses, it may be said that the action of the chemical on clover, under the limitations of soil type outlined above, is the most striking. Clover gradually disappears over a period of years when the ammonium sulphate does not have too much alkalinity to counteract. If the opposite condition prevails, then the clover will persist. The effect of the chemical upon goose grass is comparable to that upon clover.

CRAB GRASS CONTROL UNCERTAIN.

When it comes to the question of crab grass control by means of ammonium sulphate it may be said that greenkeepers and turf enthusiasts are divided by their opinions into two armed camps. Some say yes, some say no, and say it profanely. It is my personal opinion that the compound is over-rated as regards its effect upon this weed. At the best this chemical only seems to discourage the crab grass in a measure. The result is not clean cut.

Referring again to the excerpt from Mr. Valentine's article as given above, you will note that he has turned to the use of arsenate of lead for the control of chickweed this matted growth having appeared in the fairways and greens in spite of an eight-years consistent application of ammonium sulphate. They have had the same experience with chickweed at the Pine Valley Club, at Clementon, N.J. In the years prior to 1927, tons and tons of ammonium sulphate had been applied to the fairways and greens, and yet the chickweed consistently increased. It was entirely cleaned up in one season as a result of the grubproofing operations during 1928, using arsenate of lead.

Prior to the advent of arsenate of lead into the turf maintenance system, ammonium sulphate was the only chemical which gave a measure of weed-control results. It is still the only chemical which reacts against clover, providing there is not too much lime content in the soil to be overcome. I say the only one, because clover is apparently entirely indifferent to the presence of arsenate of lead in soil, and grows normally in grubproofed soil provided the latter is not too acid in nature. The sulphate is slow in its action on weeds, and will give only this degree of results when soil conditions are favourable. Arsenate of lead, on the other hand, is quick in its action on the weeds it affects, gives a very high percentage of control, and will work in *any* soil, regardless of whether it is acid, neutral or alkaline. For the control of such matted-growth weeds as crab grass, chickweed, and the death-defying *Poa annua*, the compound has no equal at the present time In my next article I propose to discuss the use of arsenate of lead as a weed-control agent, detailing its weaknesses and strong points, bringing out the more important points to be observed in its use for this purpose.

Watch Construction Pitfalls.

By O. J. NOER.

BUILDING committees charged with the construction of new courses are rarely conversant with the basic principles underlying the production of good turf. In their zeal to reduce construction costs they are often penny-wise and pound-foolish. Essential fundamentals are omitted for the sake of economy, and the club is forced ultimately to expend huge sums to effect turf improvement. Incidentally the club revenues are seriously restricted during the first few critical years, because golfers are not easily induced to join and retain membership in clubs possessing poor turf on fairways and greens.

Terrain and accessibility are usually considered more important in the selection of a golf course site than adaptability of the soil for turf growth. Now that manure is scarce and expensive, farmers in the vicinity of large cities are not maintaining soil fertility, anticipating early sale for sub-division or golf course use, so the soil may be badly depleted if the course is established on farm land. Failure to recognise this has been disastrous to many new clubs.

CRITICAL PERIOD.

The first weeks following seeding are most critical, and determine success or failure in obtaining dense uniform turf quickly. Occasionally poor turf can be traced to unfavourable weather, but more frequently it is the result of adverse soil conditions, usually improper texture, insufficient drainage, or depletion of essential plant food elements. The physical condition of heavy soils cannot be successfully modified after turf is once established, and in surface application certain fertilising elements do not diffuse rapidly into such soil. Failure to modify soil and provide plant food prior to seeding hampers any subsequent attempt to turf improvement.

Neglect to provide soil of suitable texture (refers to the size of the predominating soil grains, and silt or clay), during construction of greens is responsible for more distracted green chairmen and greenkeepers than all other mistakes combined. The extravagant claims of some bent enthusiasts, that stolons will grow anywhere, might lead one to suppose that bent grass will thrive on cement slabs. While bent seems to grow under a wide variation of soils, good putting surfaces are not easily maintained on greens constructed of heavy silt or clay.

The character of the surface four-inch layer of soil is most important. If too sandy it has such low water-holding capacity that the surface soil dries out rapidly during hot weather. Clay soils, while they have a greater capacity to retain water, become so hard during the summer that the ball will not bite when pitched to the green. The very fine pores between the soil particles impede the free movement of water and the surface soil, following heavy watering or rains, may become water-logged. This restricts the soil supply of air, and interferes with normal growth. In extreme cases where surface drainage is imperfect, excess water saturates the depressions and drowns the turf.

WATERING DANGER.

The tendency is often to apply too much water in attempts to provide surfaces which will hold the ball. Where soil of proper physical condition is used during construction, good turf can be maintained with less effort and expense. Incidentally, grasses tend to grow coarser on heavy than on lighter soils. All things considered, the best soils for greens are sandy to medium loams. These provide ample water-holding capacity, are plentifully supplied with air, and move water rapidly.

In past practice manure was extensively used to modify the texture of the surface soil layer, and in rare instances thick layers were imbedded in the green, anticipating deeper root development. These layers are the source of much trouble, and uneven settling leaves irregular surfaces. During winter, water stands in the depressions and winter-kill results. Worms seek and multiply in these manure layers, and are hard to control. The main feeding roots of turf grasses occupy the surface soil, and are not benefited by plant food imbedded in the green. While less soil is required to affect soil modification than sand, there are several factors which must be considered in connection with its use. Unless thoroughly rotted and composted, large numbers of troublesome weeds may be introduced. When large amounts of manure are used, worms become more numerous, and the abundant plant foot, particularly nitrogen, encourages coarser growth of the bent wherever possible. Manure should be dispensed with, and sand or other suitable material substituted, applying the plant food requirements in other forms, so as to control the character of growth.

The large amount of sand required to effectively modify heavy soil, and the relatively small quantity of clay required to change a sand is rarely appreciated. A sand contains 20 per cent. or less of the fine clay particles, whereas a clay soil is any containing 30 per cent. or more clay, the balance may be sand. This addition, if only 10 per cent. clay, may convert a sand into a clay soil. Hence, relatively large amounts of sand should be used with clay soils, and only small quantities of clay suffice for sands.

Fine grained sands are not suitable for modifying soil texture. The coarser sands are to be preferred, and can be depended upon to materially lighten heavy soils if sufficient quantities are used. So far as possible select sands, free of lime carbonate, otherwise clover control may be difficult, because clover thrives in soil abundantly supplied with lime.

AVOID BLUE CLAYS.

Soils bordering streams are often underlaid wit a bluish grey, heavy clay subsoil, usually stained with brown concretions. The bluish colour is an indication of poor drainage. These subsoils are so compact that they are impervious to water, and, hence, unsuitable for use even in the base of the green. Clubs will be amply repaid for the slight additional cost occasioned by hauling suitable soil from adjacent higher land.

Thorough drainage is fundamental, and best provided during construction. Most golfers think of drainage in terms of playing conditions, realising earlier play is possible in the spring, later play in the fall, and following heavy downpours of rain if provision is made for rapid removal of water. Drainage should be considered primarily in relation to turf maintenance and the other benefits will follow naturally.

gin growth first on well-drained soils. Excess moisture prevents soils from attaining temperatures at which growth commences. Sandy soils are commonly referred to as early soils. They are sufficiently porous to permit excess water to pass down through them. As the season advances, turf on areas saturated with water rarely makes satisfactory growth, and may even succumb, because the roots fail to obtain needed oxygen.

One club has re-seeded two fairways every spring for years. In this way a fair growth of turf was maintained during the summer, only to disappear in the late fall and winter. Poor soil rather than drainage was blamed, because a large ditch and haphazard lines of tile had been installed. These fairways run parallel and adjacent to two steep slopes. During the late fall and early spring, seepage water oozes out from the hill sides and effectively kills the grass.

Permanent turf cannot be maintained until lines of tile are installed above the fairway, and along the slope to cut the lines of seepage. Had the condition been recognised, not only money would have been saved, but better fairways and a more contented membership would have been the result.

Both surface and under drainage of greens are important. Surface drainage, especially so on the heavier soils where movement of excess water down through the soil is slow at best. Sandy soils being more porous permit more rapid movement, and, hence, failure to provide for surface drainage is not usually so disastrous. When contours permit, excess water moves off much more rapidly than it passes down through the soil. By providing good surface drainage, severe winter damage is frequently avoided. During mild spells when the deeper soil layer is still frozen, surface water formed as a result of melting snow or from falling rain, cannot pass down through the frozen soil, and is a source of grave danger.

DRAINAGE REQUIREMENTS.

More attention is being given to tile drainage of fairways, and the benefits of employing competent drainage engineers to design the system is being realised. The depth and distance between lines depends upon the kind of soil. Lines must be placed closer on heavy than light soils. Shallow tiles are a menace, subject to shattering from alternate freezing and thawing, and do not receive water from great distances laterally.

When greens are located near slopes look out for seepage water, and, if present, cut it off above the green, for lines of tile in the green rarely effectively receive the water.

Tile should be placed deep enough to effectively cut the seepage and obviously should run at right angles to the direction of flow. It is advisable to back-fill with pea gravel or other similar material.

If greens are to be planted with bent stolons select one of the better strains. These strains produce finer turf, grow more erect, are resistent to brown patch, and are not so prone to grow coarse when fertilised. Undoubtedly, much of the present crticism of bent stolon greens is traceable either to the use of poor strains or improper care. After greens are once put into play they are difficult to change. This not only involves considerable expense, but puts the greens temporarily out of play.

STOLON HANDLING.

The various stolon nurseries supervise planting or supply detailed instructions, but these are some points often overlooked. Obviously planting should be sufficiently thick to permit rapid closing. Stolons not more than a year old are most vigorous. Every effort should be made to plant stolons just as soon as received. They are usually shipped in burlap bags, chopped and ready for planting. If permitted to stand in the bags, heating takes place, and the vitality of the stolons is lowered. Should rainy weather prevent immediate planting, stolons should be stored in a cool place, and if possible spread out in thin layers to prevent heating.

The amount and kind of fertiliser to use on greens depends upon the character of the soil. Some acid phosphate often encourages root development, and can be safely applied at rates of 5 to 10 pounds per 1,000 square feet. It is best applied prior to planting, and then raked out the surface soil. Initial applications of nitrogen should be moderate so as not to encourage too coarse growth. If sulphate of ammonia is used it is best applied a week to ten days in advance of planting, to reduce the danger of injury.

Until a root system is established, the surface soil must be kept moist. This may involve sprinkling twice a day. If the soil is dry at the time of planting, more water may be required at the first sprinkling, because dry soil absorbs water slowly.

Many bent greens are ruined during the first couple of months. They must be cut closely from the start. Inexperienced greenkeepers permit the bent to grow unhampered, expecting the bare areas to close in more rapidly. Long runners develop, grain and nap appear, and the turf becomes tufted.

FERTILISING.

Early and persistent cutting is essential to the development of erect turf. Clippings should be allowed to fall, and the greens should be topdressed frequently. Nitrogenous fertilisers should be applied, the amount and frequency of application depending upon the colour of the turf, character and rapidity of growth.

Seeded greens usually require more generous fertilisation than those planted with stolons. Grass seed contains so much less stored food than stolons that mineral plant food elements must be obtained from the soil immediately growth begins. Abundant phosphoric acid is particularly important to stimulate root development and ensure a uniform stand. Not less than 10 pounds acid phosphate should be applied per 1,000 feet of surface, and worked into the soil prior to seeding. Some nitrogen should be applied also, about 3 to 5 pounds per 1,000 square feet, if from sulphate of ammonia, and 30 to 40 pounds if one of the better organic nitrogen fertilisers are used. Too much soluble fertiliser must be avoided to prevent injury to the sensitative young seedling. The danger is lessened by making applications somewhat in advance of seeding.

Failure or sparse turf are altogether too common on new fairway seedings, and are often traceable to insufficient plant food. Once obtained, thin turf is difficult to improve, especially on heavy soils.

Last fall, a new club with a considerable farmer membership ignored what later proved to be sound advice, and seeded fairways without fertilisation. This spring these fairways were entirely devoid of turf. The short sparse grass which developed last fall succumbed during the severe winter. This spring, before reseeding landing areas and approaches were treated with generous amounts of acid phosphate and moderate amounts of nitrogen. Six weeks later, when the sparse grass on the unfertilised areas was one half-inch high, the fertilised areas carried dense grass at least two inches high. Had the fairways been fertilised last fall, seed and soil preparation would have been saved this spring, and play would have been possible early this year.

Manure is not always essential, particularly on soils of good physical condition, namely sandy loams, loams, and silt loams. On heavier soils generous applications disced into the surface produces marked improvement of physical condition. If time permits this same effect can be obtained by growing a green manure crop. One of the legumes, cow-peas, soy beans, sweet clover, etc., should be used, because they draw upon atmospheric nitrogen, and thus enhance the soil supply. Legumes are heavy phosphorus and potassium feeders, and should be fertilised with a fertiliser containing these ingredients. Nitrogen is not necessary.

As already mentioned, phosphorus stimulates root development, and hence is most important. A dependable chemical method for determining available phosphorus in the soil has been devised recently, and serves as an excellent guide in recommending phosphorus needs. Since phosphorus exerts such marked effects on root development, maximum benefits are only obtained when applied in available form, and worked into the soil prior to seeding. Applications of 250 to 350 pounds of acid phosphate usually suffice, but when the soil contains only small amounts of available phosphorus 500 to 600 pounds may prove more effective.

While nitrogen can be supplied later, some should also be used at the time of seeding. The amount depends upon the type of soil and fertiliser material used. Soluble fertilisers must be used sparing to avoid injuring, whereas organics, such as cottonseed meal, poultry manure, milorganite, etc., can be applied in amounts ranging from 750 to 2,000 pounds. Sandy soils may need some potash which is best supplied from muriate of potash, usually 100 to

200 pounds per acre suffice. Since this material is water soluble large applications must be avoided or damage may result.

PLANT FOOD FAILURES.

Failures resulting from the substitution of concentrated plant food materials have often been due to one or both of two causes. Selection of improperly balanced fertilisers or too small applications. A twenty-ton application of manure supplies 150 to 200 pounds nitrogen, and 75 to 100 pounds phosphoric acid. How can several hundred pounds of commercial fertiliser be expected to produce equally good results?

LOW COST LEADS ASTRAY.

To sum up, the success of a new course from a turf standpoint depends primarily upon proper soil conditions, including adequate drainage, good physical condition, and ample plant food. Then, if high-grade seed is correctly sowed in a good seed bed, a fair break in weather will ensure good turf on greens and fairways. Construction committees should stress these points rather than low cost figures. The slightly larger expenditure will be more than offset by lower initial maintenance costs and a more contented membership.

Why we have Weeds; how we prevent 'em,

By B. R. LEACH.

IN "Golfdom" I discussed the virtues and weaknesses of ammonium sulphate as a weed control agent, pointing out that the value of the chemical in this regard rests upon the fact that it tends to make the soil more acid in nature, thereby making the latter more suitable for the growth of the fine turf grasses, and less so for the growth of many weeds, which prefer a sweet or alkaline soil. It was shown that ammonium sulphate was most efficient as a weed control agent in soils of a neutral type, that is, midway between acid and alkaline, but that where the soil was naturally endowed with limestone or where the water used on the course was impregnated with lime, the ammonium sulphate was labouring under too great a handicap, and could not be expected to give satisfactory weed control. Under the circumstances ammonium sulphate cannot be correctly considered as a weed control agent for universal use. Soil conditions must of necessity be just about so so for the chemical to function.

ANALYSE YOUR SOIL.

Apropos of the above paragraph, the question may be very aptly raised as to how the officials of a given golf course are to know whether the use of ammonium sulphate will produce results in controlling weeds on their particular course. This is a fair question, and can be fairly answered. As a matter of fact the officials of not one golf course in ten have any adequate knowledge of the soil composing their course, or the soil, sand, etc., they are using for topdressing purposes. Many of these golf courses, struggling along under a load of expensive maintenance troubles, would be well advised in spending the small amount of money required for the services of a competent soil technologist, who in a few days' time would thoroughly examine the fundamental nature of the soil making up the course, determining whether it was naturally acid, neutral, or alkaline in nature, and whether its original nature had been changed by the fertilising programme of the club during the previous years. At the same time he could examine the chemical nature of the water supply and check up on the degree of acidity of the ingredients of the topdressing. With this information in hand it would be a simple matter, for instance to ascertain whether you can expect anything from the use of ammonium sulphate. Many a golf course is using ammonium sulphate, and then applying topdressing so alkaline that it more than counteracts the acidity of the sulphate. A proper soil examination would disclose such a condition, and all possible corrective measures could be applied. For the services of a competent soil technologist it is advisable to get in touch with your state experiment station.

WEED ORIGIN AND DISPERSION.

What is the origin of the innumerable weeds found in the majority of golf greens? They do not occur spontaneously. Rather they are the result of a definite phase of Nature's handiwork. If you cast your eye over a golf course, taking in the rough, fairway, and green areas, you will see weeds everywhere. Each and everyone of these weeds is growing with one definite object in view, namely, to reproduce itself by means of *seeds*. When these seeds ripen Nature scatters them largely through the instrumentation of wind and water, although birds and other animals play some part in the process. As a result of this constant weed seed production and dissemination, the soil surface *everywhere* is well supplied with weed seeds, and if given half a chance they will germinate and grow.

Under the circumstances, in considering the question of weed control by artificial means, we are concerned with only the upper soil layer to a depth of one-half inch at the very greatest, and usually not more than the upper eighth inch. If by any means whatsoever we can prevent those weed seeds already present at or near the surface of the soil from germinating normally, and if in addition we can prevent the normal germination of those weed seeds, which are subsequently blown or washed on to the turf, then we will have gone a long way toward lessening the weed problem in fine turf.

STEAMING THE TOPDRESSING.

The treatment of topdressing by means of live steam for the purpose of killing the weed seeds present therein is having considerable vogue in various section of the country at the present time. It was very minutely discussed at the 1928 meeting of the Green Section in New York. The discussion brought out the fact that there were a few strong adherents of the method, and many who questioned whether it would pay to inaugurate the steaming system.

There is no doubt that the proper steaming of topdressing will kill all weed seeds present therein, and to that extent will lessen the weed problem on turf topdressed with the steamed compost, but there are other aspects of the problem which should be thoroughly considered before embarking on a steaming campaign.

In the first place, before you begin topdressing with this steamed weed-seed-free soil it will be necessary to take out all the weed growth already present in the turf to be topdressed, for the plain and simple reason that this steamed soil will have no effect whatever on the weeds already present and established. Now it is relatively easy to take out dandelion, goose grass, plantain, etc., but as anyone knows it is not quite so easy to make a clean job of the chickweed, crabgrass, fennel, and other weed growths of a *matted* and patchlike growth.

Furthermore, after you have begun your system of topdressing with steamed, weed-seed-free topdressing, how about all the weed seeds that are going to blow and wash on to the green? The steamed topsoil won't kill these new arrivals. Rather, they will germinate and grow just as usual. So that in the last analysis the steaming of topdressing helps somewhat in the handling of weeds, but it only covers about one-third of the problem, leaving the other two-thirds as wide open as ever.

CARBON DISULPHIDE METHOD.

The laborious process of steaming all topdressing often costs much money, and it is doubtful if the labour and cost involved .s always justified. Had I been satisfied of the wisdom and advisability of treating topdressing for the control of weed seeds, I would long ago have published the details of a method of treating this material with carbon disulphide, whereby all the weed seeds are killed and the soil freed of adverse bacteria and fungi. The cost of treating topdressing by the carbon disulphide method is reasonable. The fact that it might not pay to treat topdressing in this way has caused me to withhold the details of the method, as there are always a lot of novice green committee chairmen ,who will jump at any new method, and involve themselves, their greenkeepers, and their clubs in a lot of useless expense and trouble.

In fact, the smug complacency if not utter indifference with which the average golf club turns over a quarter of a million dollars' worth of golf course to the machinations and tender mercies of the newly-elected, novice green committee chairman is to me the most astounding of suburban phenomena. Apparently the ability to fill teeth so the fillings will stay in more or less permanently, to make money in the coal and lumber business, to be able to cut off a leg or remove an appendix, or what not, are often considered to constitute an admirable and complete training for the growing and preservation of fine turf.

The mental condition of some newly-elected chairmen is a most interesting study, from the psychological standpoint. In the first place, as Disraeli said of Gladstone: "He is inflated with the exuberance of his own pomposity," or in plain Americanese—all swelled up like a poisoned pup. His attitude or studied pose of pseudo patronising tolerance toward the seasoned greenkeeper is maddening to behold.

The problem of the hard-headed green committee chairman will require a great deal of research before it is solved. Fortunately the weed problem is not quite so complicated.

CORRECT AND INCORRECT FERTILISERS.

The fine turf grasses need only certain fertilisers for their best growth. As a general rule an adequate supply of well rotted manure together with available nitrogen in the form of ammonium sulphate, synthetic urea, etc., are all that is required. The rotted manure contains sufficient phosphorus and potash for the modest needs of fine turf. Under the circumstances the application of potash and phosphate fertilisers results in no appreciable benefit to the turf, but on the other hand does set up a soil condition very favourable to the growth of weeds, for the plain and simple reason that most weeds make a better growth when potash and phosphorus are present in the soil in abundance. Consequently, when such fertilisers as acid phosphate, sulphate of potash, bone meal, etc., are applied to turf, as is still the common practice on many golf courses, the weeds benefit decidedly more than does the grass. The continued use of this type of fertilisers invariably results in a good stand of clover in the greens, together with ever-increasing patches of such matted weeds as chickweed. Lime, either applied as such or inadvertently as an ingredient of sand or soil in the topdressing, also stimulates weed growth, while its effect on the fine turf grasses is the exact opposite.

Under the circumstances is is highly advisable to have a care in mapping out a programme of fertiliser application. There is absolutely nothing gained by the application of unnecessary fertilisers with the subsequent expensive necessity of removing the resulting undue weed growth.

WATERING.

Fine turf is very shallow-rooted as grown on the present-day golf green, whereas the weeds are as a general rule relatively deep-rooted. In some cases they are tap-rooted. Under the circumstances they can withstand a greater degree of soil surface dryness than can the shallow-rooted grasses.

Careless and indifferent watering consequently gives the weed content of a green the edge every time. If the surface soil of a green is allowed to dry out unduly it can, of course, be brought back by careful watering, but the grass is given a decided check during the process, a check from which it recovers much more slowly than do the weeds.

The philosophers tell us that the wages of sin are death. In greenkeeping, the wages of such sins as carelessness, ignorance, and indifference in the management of fine turf are invariably an abnormal amount of weed growth in the greens.

It may be stated almost as an axiom that, regardless of all the methods employed in controlling weeds, *some* hand weeding will be necessary, as a sort of " mopping-up " process. This is the case because no method or combination of methods will give 100 per cent. weed control. Since this hand-weeding is necessary to a certain extent it would seem advisable to use common sense in the management of the operation, and to so conduct the operation that the most good is obtained for the money expended.

With most clubs the weeding of the greens is made a sort of annual event and occurs when the crab grass begins to give indication of taking the green body and soul. Aside from this annual weeding, they do very little weeding during the balance of the growing season. This is a fundamental mistake in fine turf management, and can only result in poor and thin turf.

Instead of one grand orgy of hand-weeding at the height of weed growth the operation should be made an important part of the routine work throughout the growing season. As a result of this early weeding the fine grass has its own way, and provided proper fertilisation and topdressing is practised, the turf will be thick and heavy by the time crab grass begins to make appearance. Under the circumstances, the soil surface will be crowded with fine grass, and the crab grass and other seasonal weeds will have greater difficulty in getting established.

In the last analysis, the weed control problem is intimately bound up with every other phase of turf management, and as stated above, mistakes in the handling of turf hurts the grass and give the weeds the edge.

What I have said above may sound to a certain extent like old stuff. Old it may be, but, nevertheless, it is true. I have taken the opportunity of repeating these seeming platitudes because they must still be borne in mind by the greenkeeper, even if he institutes the use of arsenate of lead on his course as a means of controlling the great bulk of weed growth by methods which I shall describe in another article. The chemical will control many of the most noxious weeds in fine turf, but not all of them, hence good turf management is an essential adjunct to its use.

Select Control of Weeds Explained,

By B. R. LEACH.

IN "Golfdom" I have discussed the pros and cons. of ammonium sulphate as a weed-control agent, while the importance of proper fertilisation and management of turf have been stressed in another article from the weed control angle. While it is vital that the greenkeeper be thoroughly versed in both the theory and practice of the above phases of turf maintenance, nevertheless, in themselves, they do not furnish him with ammunition adequate for a winning battle with the weed problem. It would appear that I can wind up this series of three articles on weed control in no better manner than by supplying him with a few soft-nosed cannon balls.

Weeds and the fine turf grasses are all plants, obvious as it sounds. Consequently, if you have a turf in which both are present, and wish to eradicate the former by chemical means, it is good business to watch your step. Don't get too rough in your tactics, or you will succeed in eradicating not only the weeds, but the grass as well. To succeed in the quick elimination of weeds by chemical means you must use what is technically termed a *selective* agent. You might, in ordinary parlance, refer to it as having a discriminating action, if we can attribute such a quality to such an inanimate material as a chemical. Iron sulphate, for instance, has been known for years as a weed control agent. Theoretically, at least, you can spray a mixed turf of weeds and grass with this compound, and the weeds will die while the grass will be unharmed. Theoretically, this may be true, but in actual practice the compound is tricky and uncertain. You never know what the ultimate result will be, and often the grass is killed. Greenkeepers are afraid of it, and justly so. Consequently, it has never had much vogue in turf maintenance circles. The compound lacks discrimination, or, in other words, it is not foolproof.

SELECTIVE CONTROL AGENT.

Arsenate of lead, on the other hand, from the standpoint of its use on turf, is a striking example of a successful selective control agent, in that it is rich, juicy meat for the majority of fine turf grasses, and poison to the majority of weeds. In order to explain this fact, suppose we consider briefly the chain of chemical events which occur when arsenate of lead is mixed with soil in which a mixed stand of fine grass and weeds are growing.

When arsenate of lead is added to soil it is acted upon chemically by the soil solution, or, in plain language, the soil moisture.

This soil solution or soil moisture is not just simply water, as a great many people think. Rather, it is water in which are dissolved a great many things, such as phosphates, nitrates, sulphates, potash salts, etc. It is from this soil solution that the plant obtains a portion of its food. This soil solution, acting on the arsenate of lead, causes a chemical change to take place as regards the latter, or, in chemical jargon, " breaks it down," with the result that we then have in the soil some soluble arsenic, some *basic* arsenate of lead, this being virtually inert as far as toxity to grubs worms, and weeds is concerned, and some ordinary arsenate of lead, which has as yet been untouched, since the capacity of the soil solution is such that it can break down only a comparatively small amount of arsenate of lead at a time. The process, however, while relatively slow, is continuous, and ultimately all the arsenate of lead undergoes this chemical change, with the result that in time the arsenate of lead loses its grub, worm, and weed controlling virtue, and additional arsenate of lead must be added to the soil to restore its grub-proof condition.

DOES ARSENATE OF LEAD DOOM SOIL?

The opinion is still held in some quarters that the continued addition of arsenate of lead to turf will ultimately result in the ruination of the soil due to the cumulative action of the chemical. From the theoretical chemical standpoint ,such an ultimate soil condition 's improbable, if not impossible, while in actual practice turf treated eight years' ago with relatively huge applications of arsenate of lead is still going strong.

As stated above, one of the products of this chemical action between the soil solution and arsenate of lead consists of *soluble* arsenic, or, in other words, the soil solution or soil moisture, as a result of the chemical action, contains some arsenic in solution, and consequently capable of being absorbed by the plant roots present in that soil.

When the roots of a grass plant, as, for instance, creeping bent, come in contact with this soluble arsenic in the soil solution, one of two things happens, but which one we do not as yet know any more than we know why a chicken crosses the road or a canary bird sings. Either the roots of the grass absorb the soluble arsenic out of the soil solution and find it palatable, or they possess the ability of taking their regular soluble food out the soil solution and rejecting the arsenic. At any rate, the vast majority of fine turf grasses thrive in soil containing arsenate of lead. Not so the majority of weeds commonly found in fine turf. When the roots of these plants come in contact with the soil solution containing soluble arsenic, they apparently absorb it, with the result that the weed is poisoned by degrees, and ultimately dies. This reaction is evidenced to the close observer by the stunting of weed growth following the application of adequate amounts of arsenate of lead to the turf, and the gradual yellowing and ultimate death of the individual weed. This reaction is especially noticeable with such rank growing weeds as crab grass and chickweed. It can be mathematically measured in the instance of a solid mat of chickweed, by pegging the outer boundaries of a specific patch of this weed prior to the institution of a programme of lead arsenate treatments.

SLOW DEATH TO POA ANNUA.

In the case of such relatively inconspicuous growths as *Poa annua*, the elimination takes places with the greenkeeper hardly aware of what is going on, or as the poet says, " unheralded and unsung."

So much for the weeds already present and in full growth prior to the institution of the programme of lead arsenate applications. How about the weed seeds which rain on to the turf with every puff of wind and swirl of rain? Of the numerous species of weed seeds which locate on an arsenated green, many are killed as soon as the seed takes up some of the soluble arsenic, and before they even sprout, while many others, while they may germinate, are, nevertheless, stunted in growth, cannot compete with the heavy turf grass growth, and fade out of the picture.

As stated in a previous article, we are concerned as regards the weed problem in fine turf with only the upper quarter to half-inch of surface soil, since weed seeds present in the soil below this depth are ordinarily not sufficiently strong to germinate and push up through a greater depth of soil. The problem of weed control, therefore, narrows down to that of so treating this surface soil layer that weeds already present will die, and weed seeds subsequently deposited thereon will not germinate normally, but on the contrary will die. Furthermore, on greens where topdressing is practised, such topdressing must also be rendered weed-proof.

WEED CONTROL DIRECTIONS.

I have, in previous articles, gone into detail as to the best methods of applying arsenate of lead to fine turf, and the reader is referred to these previous articles for specific directions. It will, no doubt, however, be advisable at this time to make a few recommendations for the use of this compound purely as a weed-control agent for those who have no particularly pressing grub or earthworm problems confronting them.

Let us suppose that you have a green with a heavy weed content, and you are desirous of adopting the arsenate of lead method of control. If you are desirous of obtaining quick action and sharply-outlined results, it is advisable to use five pounds of lead arsenate per one thousand square feet of turf, applying this amount of the chemical in one application, and taking care to secure an even spread. The question of evenness of application cannot be over-emphasised, since it is obvious that if the chemical does not come in contact with a given weed that weed will not be killed. Uneven-ness of application results in uneven weed kill or spotty control, as some would term it, and this can be corrected only by again arsenating those spots in which the weeds persist. The above application will go a long way towards cleaning up such weeds which are so difficult of removal by ordinary hand weeding.

The removal of these type of weeds by hand results in bare spaces in the turf and necessitates the insertion of plugs wherever a matt of weeds is removed. In addition to being laborious and expensive, it usually has a tendency to make a rough green, no matter how carefully the operation is performed.

By the use of arsenate of lead, this " plugging " is rendered unnecessary. As the weeds begin to feel the effects of the arsenic they become stunted in growth, take on a sickly appearance, and gradually fade out, during which time the bent grass in the immediate vicinity makes a heavy growth, pushes in and fills up the spot formerly occupied by the weed. So quiet and orderly is this transformation that it is not apparent unless certain weeds or matts of weeds are marked and maintained under consistent observation.

Inasmuch as the topdressing material teems with weed seeds, arsenate of lead must be applied with each topdressing application in order to maintain the so-called weed-proof surface layer. For this purpose the chemical should be applied at the rate of one-half to one pound per thousand square feet of turf with each topdressing. For light topdressings, use the half-pound rate, while with heavier applications use the pound rate.

Crab grass is probably the most annoying of weeds in fine turf, not only on the greens, but the fairways as well. Arsenate of lead will kill it off at any stage of its growth, and on arsenated greens it is rarely much of a problem. For the control of this weed on fairways, where consistent topdressing is not practised, it is best to apply the chemical just as the crab grass is beginning to sprout (250 pounds per acre). Of course, you can apply the arsenate at any time and clean up the crab, but it might be well at this point to bring up a point as regards fairway turf which golf course officials will do well to consider carefully. It is my candid opinion that crab grass is the most important cause of poor and weak fairways that we have to contend with on golf courses. Consider for a moment what occurs on the average fairway year after year. In the spring the fine turf grasses in the fairways, that is, what fine grass there is present, has little competition, and, if the rainfall is sufficient, grows nicely. Along in June or thereabouts the crab grass begins to sprout, and in a short time is master of the situation. The fine grasses are hopelessly outclassed by this rank-growing weed, with the result that by the end of the growing season, when the crab is killed by the first heavy frost the small proportion of fine grass remaining in the turf after the summer's struggle with the crab is weak, thin, and in just about the finest condition ever to be heaved out by every frost and winter-killed. Is it any wonder that the fairways get poorer and poorer each year? Manuring, fertilising, and watering the fairways will not necessarily insure you good turf; *it may only give you better crab-grass.* It might be better to spend some money getting rid of the crab grass before you try to grow anything else. One of these days I propose to write in "Golfdom" on the "Problem of the worn-out fairway, and how to bring it back." I have a few ideas on this subject which may prove interesting, and furnish food for thought for the up-and-coming greenkeeper.

Arsenate of lead has no *direct* nutrient value for grasses, but treated and untreated plats, side by side, show that the majority of grasses grow more luxuriously in arsenated soil than in soil not so treated. The explanation of this grass stimulation lies, no doubt, in the fact that arsenate of lead does a great deal in controlling nematodes and adverse bacteria and fungi which infest all grasslands and tend to slow down the growth of vegetation. Consequently, it may be said that arsenate of lead has an *indirect* nutrient value for grasses.—B. R. Leach.

Arsenate of lead, at the dosages recommended for grub-control, is death to Poa annua, and it is having considerable vogue in the East as a means of ridding greens infested with this grass, which to most golf clubs is highly objectionable. Under the circumstances, would not advise the use of this chemical by greenkeepers who wish to retain their Poa annua greens.—B. R. Leach.

How we learn to be Better Greenkeepers at the Amhurst School,

By WILLIE OGG,

Professional, Worcester (Mass.) Country Club.

I THINK I have been in the golf game long enough, both in the pro end and in the practical end of greenkeeping to accurately judge for myself whether this ten weeks' course I am taking here at the Massachusetts Agriculutral College, at Amhurst, is to my advantage or not.

I was influenced to take this course partly because I consider Prof. L. S. Dickinson, who gives us most of our instruction on grasses, grass seed, implements, managerial problems, and cost keeping and analysis, the most able man in this line I have ever met and partly because of the present-day insistence of the average club membership for perfection in the greenkeepers' art. I felt that if I did not learn anything of value I would be just as well off as before, and if I did find knowledge, I would finish the course a much better man.

To state that I am finding knowledge is putting it rather mildly. I am amazed really at getting by with the little practical knowledge I had when consideration is taken of the fact that the average greenkeeper knows little of motors, water systems, landscape gardening, and the seed game.

We are taught about motors by lectures and actual work on tractors and autos and power-driven lawn-mowers. We get into our overalls and find out in a practical manner by doing the job ourselves.

The proper method of installing water systems is taught us. This includes the operation of the different types of water-pumps, the loss of pressure by pipe friction and elevations, and the proper size pipe to use to assure a given pressure at the greens.

Landscape gardening is included in the course. By this we get an insight into the laying out and planting of the grounds surrounding the club house, how to do grading work to conform to the surrounding country, and the laying out of roads and paths, and the planting of trees to conform to the landscape. We do this work mostly by making models in sand.

EDUCATED AS BUYERS.

We are taught how to judge golf course equipment, more especially mowers and their upkeep, what a mower or cutting unit for the fairways should do, and the proper method of handling same. A thorough study is made of the other equipment used on golf courses, taking in the whole line necessary to greenkeeping.

Drainage is covered in this course. We are taught the use of the level, and how to set ditch grades. Special problems are worked out, and we are shown how to overcome the common problems encountered in golf courses.

We are making a very intensive study of grasses and grass seed, confined principally to those commonly used on golf courses. We study the germination of the seeds, how to identify them, how to detect impurities and weed seeds, and the method of cleaning the seed. We are shown how to identify the various grasses, using the grasses grown in the hothouse for the tests, the value of the different grasses in different parts of the country, the conditions under which they thrive best, whether they stand short cutting or not, and the soils and fertilisers best adapted to them.

Soils and fertilisers are analysed, and gone into in a very thorough manner. We are taught the chemical reaction of soils to the various chemicals, dependent on the soil conditions, and their relation to the various grasses and diseases of the turf. The diseases common to greens, such as brown patch, are shown to us. The disease germs are bred and inoculated in the grasses so that we can see for ourselves how they destroy the cells of the grass leaf. This can be plainly seen with a powerful microscope, also the effect the various chemicals have on them.

We get the business side of greenkeeping by a study of the managerial problems, and cost keeping and analysis which, boiled down, means getting a dollar's worth for a dollar.

Perhaps it may occur to some who may read this that it is not possible to acquire all this knowledge in ten weeks; if so, we would finish this course as qualified motor mechanics, water engineers, landscape gardeners, etc. With them I would agree, but I will maintain that enough knowledge can be gained in this course, providing one has practical knowledge of greenkeeping, to make oneself a very valuable man indeed. Should one choose to follow up this education combined with practical work on the golf course, I have no doubt but what he would be a very much sought-after man.

Some people are inclined to "pooh-bah" the idea that a college can teach greenkeeping, and I want to rise up in defence of this college on this subject. There is no college that I know of that professes to teach greenkeeping so the courses are given for greenkeepers to aid them in their problems, and give them knowledge that will make them better and more valuable men. I think most everyone will agree that it is hard to find a greenkeeper to-day in possession of the knowledge covered in this course, and who can gainsay the fact that any man having this knowledge would not make a better man to the club he may be with? I make bold to say that greenkeeping would soon be in the ranks of the professions if such was the case.

Soil Condition Essentials Controlled by Greenkeeper,

By MATT MELVILLE.

Greenkeeper, Southmoor Country Club.

THE matter of maintaining soil fertility is entirely up to the greenkeeper. The action of the soil does not remain stationary, but it is constantly changing, and the different elements in the soil are being transformed into energy, which makes plant life possible. It is the ability to release these elements in the soil, and transform them into plant food, that keeps the greenkeeper interested in his work.

On the average golf course we are dealing with either clay or sand, that is either heavy or light soil. There are, of course, definite classes of soil; the important ones of which are gravel, silt, loam, clay, sand and humus. Humus in its natural state is in timber land, where the soil reveals the decomposition of leafy matter. We are not very often blessed with a soil of this type to work with on golf courses, but more often with either clay or sand. In clay soil we always find some humus.

Sandy soils are always deficient in food content, brought about through excessive air circulation and drainage. Humus should be added to sandy soils to give them more body, and also add food that is rich in nitrogen. Sandy soils are always lacking in potash, and adding this element is also an improvement.

Heavy clay soils are very often rich in food values, but owing to the fineness of the particles that make up the soil, the water and air cannot penetrate sufficiently for the food elements they contain to release themselves. Sand and humus added to the heavy clay soils break up the heavy particles, bring lightness, and allow air to penetrate the mass.

Tightly-packed particles of clay out of which has been squeezed the moisture and air are practically impossible for the growth of plant life. All soil is dependent on air and moisture to produce plant life. This air and moisture is controlled entirely by the size of the particles that go to make up the soil.

Bacterial action is the agency by which chemicals in the soil are converted into plant food. This action is controlled by air and water, which are allowed to percolate through the soil.

The pressure of plant food is determined by the amount of water, because this food must be in soluble form. The temperature of the soil depends greatly upon the amount of moisture held within and brought to the surface by evaporation. A small portion of sandy soil magnified will show larger and smaller particles, surrounded by air spaces. These are being constantly changed by the action of temperature, the amount of water, and also evaporation.

When you cultivate soil you loosen the surface layer, thus forming a mulch; the loose surface of the soil or the mulch prevents the escape of moisture through capillary attraction. The mulch checks evaporation, otherwise moisture would be wasted as would be the food elements that are held in suspension.

We cannot practise the same method of cultivation on a putting green a farmer can on his crops. Our system of cultivation and mulch is made possible by topdressing.

Deep significance in Recent Turf Research.

By B. R. LEACH.

THE outstanding paper of the series delivered at the annual meeting of the Green Section held in New York in January last, was given by Dr. John Monteith, jun. Dr. Monteith is well known to the turf-maintenance world as a plant pathologist and specialist in the control of turf diseases. In this paper he outlined the scope and results of two years of experimental work in the control of brown patch by the use of lime. In experimental plats treated with ground limestone at the rate of one ton to the acre (roughly five pounds per 100 square feet of turf) the disease failed to develop, whereas unlimed turf in immediate proximity to the limed turf was virtually wiped out by the disease. The Doctor's address was well illustrated by a comprehensive series of lantern slides. Needless to say the paper made a profound impression upon the gathering of turf enthusiasts present at the meeting. It would appear, after several years of intense misery with the brown-patch scourge, culminating in the debâcle of 1928, when almost all golf courses in the East were rendered *hors de combat* by this disease, that relief is in sight, and incidentally by the simplest of methods, namely, the application of ordinary ground limestone.

While the first reaction of Monteith's work will be a feeling of intense relief in the thought that brown-patch is at least in the way of being conquered, there is, nevertheless, a much deeper significance attached to this particular piece of research than is readily apparent to the casual observer. I refer to the value of lime in the turf-maintenance scheme, aside from its value in controlling disease, and in order to bring out this point clearly it will be necessary to review the history of greenkeeping during the last twenty years.

That period in the history of American greenkeeping prior to 1920 has been facetiously referred to by the cynically inclined as the "bone meal" or "lime" era. During this period much lime was used on golf courses, and in fact the seasoned greenkeeper applied it to the turf as a matter of course, just as he applied manure, fertilisers, etc. With the advent of the Green Section and the subsequent era of intensive turf research at Washington, the use of lime was discouraged by the technical fraternity for good and sufficient reasons. In the first place it was found that the application of lime encouraged the growth of clover in fine turf, and since most golf courses were highly desirous of ridding their greens of this growth they ceased the application of lime. Further research showed that lime encouraged the growth of certain weeds, which was again a good and sufficient reason for discontinuing its use. Then, as time went on, it was found that the lime already present in the turf could be gradually eliminated from the soil by the use of ammonium sulphate, that this material was a very good fertiliser for turf, and that the bent grasses grew very well in soil rendered acid by the use the sulphate. Thus came into being the " acid soil," or " ammonium sulphate " era of American greenkeeping, during which period the application of lime to American golf courses became a lost art.

ACID SOIL TROUBLES.

While we will readily admit that much good turf was grown during this acid soil era, we will also willingly and gladly admit that this system of soil management had some very serious drawbacks aside from the prevalence of brown-patch. We will be perfectly delighted to see the acid era pass into oblivion, and stay oblivated. Why? Well, if there is anything meaner, nastier, and more ornery to handle than the general run of acid soils we have yet to meet up with it.

Consider a typical tight clay soil such as many golf courses are cursed with. These soils are invariably acid in nature, slow to drain, bake like a brick during droughts, and are a pestilential mess as far as the growing of fine turf is concerned. Now, if a well-informed farmer were undertaking to grow crops on such a soil he would begin operations by applying several tons of lime per acre. Why? Because the lime, in the course of a reasonable period of time would correct the soil acidity and thereby automatically "open up" the soil, making it friable, quicker draining, and much less inclined to bake when dried out. In other words the application of lime to tight soils is a recognised procedure in modern farming.

However, during the " acid soil " régime we were denied the use of lime on such tight soils where the bents and other fine turf grasses were to be grown, because, as stated above, it was held that such grasses were best grown in acid soil. Consequently, the greenkeeper was put to the necessity of using other devious and relatively expensive methods of " opening up " tight clay soils. As far as the greens were concerned he changed the nature of these clay soils by actually transforming them into medium and light clay *loams*, by the application of huge quantities of sand, and liberal applications of organic matter. When this result was obtained the soil was still acid in nature, but could be more readily handled because it was not as heavy and tight as the original clay.

THE CLOSE OF THE ACID SOIL ERA.

This system worked out fairly well from the expense standpoint as far as the comparatively small area of the greens was concerned, but it would have taken a small fortune to so treat the fairways, and the sand banks of the country would have been sadly depleted before the operation was even partially completed. As a result the fairways of many golf clubs in this country during the acid soil era have not been much to talk about. Golf club officials simply shut their eyes to fairway conditions as they actually were, and hoped for better days.

From present indications, the "acid soil" era in the history of American turf maintenance came definitely to an abrupt end at 3.30 p.m., Friday, January 4th, 1929, when Monteith read his paper at the Green Section meeting in New York, dealing with the effect of lime upon brown-patch, and if the ether waves are not lying I think I can hear the amused chuckle of more than one veteran greenkeeper who used lime in the good old "bone meal" era, and quit using it only when threatened with the loss of his job for insubordination.

THE BONE MEAL ERA RETURNS.

Why am I so firm in the belief that lime is coming back. It's a fair question, and here's the answer: In any phase of agriculture—and of course turf maintenance is a phase of agriculture—what are the factors which determine the trend in methods? Is it simplicity of operation, the cheapness of a particular method, or the fact that a crop will grow better under certain conditions and methods? Not by a jugful. It is the enemies of a crop in the shape of insects and disease, and the methods used in their control, which absolutely decide the *modus operandi* to be employed in growing that crop.

Let us say for the purpose of argument that bent grass *will* grow better in acid soil than in limed soil. That doesn't mean that from now on, in view of Monteith's results in controlling brown-patch with lime, bent grass is going to be grown in acid soil. What is the use of growing the *highest* grade of bent grass in acid soil only to have it wiped out every summer by disease? It simply means that possibly a *slightly* lower grade of bent grass will be grown in limed soil, but the *slightly* lower grade of bent will be more than compensated for by the freedom from disease. In the same way many clubs may dislike intensely the idea of using arsenate of lead for grub control, but you've *got* to use it if grubs are present, or else stand by and see the turf die by inches.

If the fine turf grasses do not grow quite so lustily in limed soil (mind I'm not saying they won't), I still believe that the use of lime will be warranted and profitable if only because it renders the taming of stubborn soil types cheap and easy. A ton of ground limestone applied to an acre of stubborn clay soil will do more in rendering it amenable to the growth of fine turf than a carload of sand, and at a fraction of the price.

WEED CONTROL IN LIMED SOIL.

There is plenty of evidence to show that clover and certain weeds are encouraged by the presence of lime in the soil. Consequently we may expect to see a return to importance in the public eye of the problems of clover and weed control in fine turf when the use of lime becomes extensive. The answer, of course, is fairly obvious. It simply means that extended and intensive research must of necessity be conducted by technical investigators for the purpose of working out simple methods o f controlling clover and certain weeds, these methods to be compatible with the use of lime. If such research is conducted in a thorough and consistent fashion by able investigators, backed by sufficient funds, it is safe to say that control methods will be evolved in due course.

LIME AND FERTILITY.

Now is a very opportune time for every alert greenkeeper to pick up his copy of " The A. B. C. of Turf Culture," written by O. J. Noer, and wear out some brain tissue by making a careful study of Chapter IV., entitled, "The Functions of Organic Matter in the Soil." In this chapter Noer details the rôle that the organic matter in the soil plays in feeding the plant growth. He shows that a soil must be in the pink of condition as far as drainage. physical condition of the soil particles, aeration of the upper soil layer, etc., are concerned in order that the organic matter may decompose at the proper rate, and thereby release its store of plant food in such a shape that the growing plant can absorb it. This is necessary because the bacteria responsible for the decay of this organic matter work best when they have adequate soil moisture and free aeration of the soil to supply needed oxygen. Noer also indicates the value of lime in assisting the bacteria in their important work of converting raw organic matter into plant food.

Under the circumstances, other things being equal, it follows that a soil containing sufficient lime will always be more fertile, and support a heavy growth of turf much more efficiently than will a similar soil deficient in lime. In other words, the lime assists, first, in putting the soil into good physical condition; this good physical condition being indicated by the fact that the soil is easily handled. It drains much more readily and quickly after a heavy rain. It is more springy and friable to the touch, and can be dug, cultivated or otherwise handled without forming into hard clods. When such a soil dries out it has less of tendency to bake. Secondly since lime does all these things to a stubborn soil it increases the fertility of the soil because the soil bacteria are then able to work on the organic matter in such a soil to the best advantage, and thereby convert this raw material into available plant food.

It follows, therefore, that an acid soil, that is, a soil deficient in lime, must of necessity be handicapped as regards its capacity to convert organic matter into plant food for the plain and simple reason that soil conditions are not at their best for maximum bacterial action. Such acid soil, when used for the growing of the turf grasses, must of necessity be " babied." It must be fed frequently with quick-acting fertilsers in order to keep the grass "on its toes."

If the use of lime becomes common on fine turf there is every probability that less of the " babying " of fine turf will be necessary. When these acid soil greens, with their present baby digestions, get shot of lime, they'll develop the copper-lined digestive apparatus of a boa constrictor, and howl for red meat.

LIME, BUT NOT TOO MUCH LIME.

In conclusion, a word of caution—this word of caution being directed especially to that type of human who swallows two tablespoonfuls of Epsom salts when a teaspoonful would serve the same useful purpose. Don't become too enthusiastic and apply lime with a shovel. When you apply 50 pounds of lime to a thousand square feet of turf you are applying it at the rate of one ton per acre. This is the rate that Monteith used in controlling brown-patch at Washington. At the present time the Doctor does not have any too much information as regards the dosage of lime to be applied, but such information will no doubt be rendered available in due course.

I personally prefer ground limestone or other form of commercially pure calcium carbonate for application to fine turf. This material will correct soil acidity, and does not possess the caustic properties of hydrated lime. Being very slightly soluble, only very finely ground material should be used.

It should all pass 100-mesh sieves, and the 200-mesh is even better. Unless the limestone is finely ground, uniform distribution is difficult, and only the soil immediately surrounding the lime particles is benefited.

About Velvet Bent,

By NORMAN HACKETT.

I WOULD refresh readers' minds with some notes on this grass which appeared in my Turf Nursery article of September " Golfing ":—

" Very often one experiment suggests another. Agrostis Canina (Velvet Bent)—the finest grass of the whole variety—has been mentioned previously several times in these articles. It is an extraordinarily shy seeder, and it is not posisble to buy this seed pure. When Dr. Oakley visited our course a year ago, the writer showed him small patches of this grass on one or two of our fairways, and he counselled us to try it out vegetatively, but we had not hitherto given effect to his suggestion. However, in June, when we saw the American Creeping Bent coming along so well, we took a single plug of Agrostis Canina turf, separated and teased it out and dibbled in a dozen root plants in a prepared nursery bed. To our delight these commenced to throw out noded stolons at the end of July, and next month we shall cut them off and plant for a stolon nursery for next year. It is early days to be optimistic, but we do not forget that the Washington and Metropolitan strains were both developed from *original single plugs*, and we shall nurse them with a great hope."

A week after this article went to press I received my mail copy of the August number of the United States Scientific Green Committee's Bulletin, and to my surprise and delight, found therein practical confirmation that the hope I entertained for this grass had already been achieved in America. Not only that—but the evidence available indicates that it makes a better and finer turf than the American strains of Washington and Metropolitan Creeping Bent, to which so much experiment and attention has previously been directed.

In this connection Sir Robert Greig, K.B.E., F.R.S., D.Sc., Head of the Scottish Board of Agriculture, last May expressed to the writer his conviction that we had in Great Britain indigenous Bents of a creeping variety which could be developed vegetatively that would be equal, if not superior, to the above-mentioned varieties. I give the American article in full:—

VELVET BENT (AGROSTIS CANINA).

By Major R. Avery Jones, Baltusrol Golf Club.

" Velvet Bent grass makes the finest and the most beautiful turf of any of the Northern grasses.

" On nearly all old seeded greens circular patches of this fine turf, varying in diameter from one to four feet, can be found. It is strange that the fact that velvet bent produces such fine turf has been *overlooked so generally*. While some attempts have been made to produce velvet bent seed, and seedsmen have advertised their mixed bent as having a large percentage of velvet bent seed, there appears to have been no real effort to produce pure velvet bent greens.

" Three years ago a turf garden was established at Baltusrol Golf Club. The garden contained, in addition to creeping bent planted in beds and rows, twelve beds of velvet bent planted by the stolon method, and three beds consisting of velvet bent patches of divot size—a total area of 5,000 square feet.

" The velvet bent stolons were obtained on the golf course early in November. They were hand-picked from edges of greens and the rough. No doubt there were dozens of different strains, varying in colour from a light green to dark-blue green.

" There being no data as to the quantity of velvet bent stolons required for a given area, each bed was planted with a different quantity, varying from a light covering to three times the quantity of creeping bent stolons recommended by the Greens Section.

" The divot planted was as follows:—

" The divots were small circular patches about four inches in diameter. They were placed on prepared ground about four inches apart. Screened soil was then applied in sufficient quantity to fill in between the patches.

" The nursery planting was finished about November 15th, and with the exception of topdressing and watering, received no further attention that fall.

" Due to the very late planting there was very little growth, but sufficient to indicate that both the stolons and divots were established. In the following spring the creeping bent grew much more rapidly than the velvet bent. The creeping bent beds were well covered in May, and were mown every day. The velvet bent grew much more slowly. However, during the summer the velvet bent began to grow rapidly, and by July every bed was a solid mat. The velvet bent had produced in the same period far better putting turf and a much more beautiful turf than had the creeping bent stolons. Despite the radical difference in planting and quantity of stolons used, there was very little variation in the quantity of turf.

" During the month of September, 1925, five thousand square feet of the velvet bent turf, and three thousand square feet of creeping bent sod—the entire nursery—was cut, and used to sod the new ninth green of Baltusrol's upper course. The approach and back of the green received the creeping bent.

" The turf was a little too young for moving, but it soon became established, and is now in fine condition, although not yet as dense as the mats to be found in the older seeded greens. It would seem that it takes three to four years for the dense mats of turf to form.

" In the treatment of velvet bent in the nursery it was found that it did not require, and in fact would not stand, nearly as much topdressing as creeping bent, and the quantity of ammonium sulphate that can be applied to it with safety is also less.

" 'Little brown-patch' has attacked the velvet bent green, but not to any greater extent than other greens. There was no loss of turf.

" As a putting green grass, velvet bent has the following advantages:—

" Excellent colour, fine texture, and a dense turf. Weeds made little headway in well-established velvet bent. Less topdressing is needed. The growth of the grass is less rapid than creeping bent, and mowing is much easier. Velvet bent appears to require less water than does the creeping bent. There are several greens at Baltusrol in which velvet bent amounts to as high as 80 per cent. of the turf; yet in those greens ' little brown-patch ' gives the least trouble.

" Whilst one cannot draw conclusions after so short an experiment, the writer has proved to his own satisfaction the following:—

" (1) Velvet bent turf can be produced from stolons in the State of New Jersey.

"(2) Topdressing must be very light. Application of sulphate of ammonia and similar fertilisers must not exceed two-thirds the quantity normally applied to creeping bent.

"(3) Surface drainage is imperative. Velvet bent, winter kills much more easily than does creeping bent.

"(4) When once established, velvet bent does not send out runners on the surface as does creeping bent."

By the first week of October, the few Agrostis Canina plants we had "dibbled in" at Keighley in June had so grown and thrown out their creeping stolons that we were able to cut them off and plant the stolens for a *stolen nursery for next year, which if* all goes well, will yield sufficient stolons by next September to make the *ultimate composite turf*.

Last month I sent to Sir Robert Greig some specimens of this grass.

(1) A plug taken from one of the few small patches in which it is found on our links.

(2) A plug taken from a plot 4 feet by 2 feet, which we had laid down in the Experimental Nursery, and which was comprised of little pieces of sod we had transferred from its natural habitat. Most of the pieces were no larger than a hearth tile—anl even then we could not get it absolutely free from Agrostis Vulgaris, which is its companion grass. This turf plot we composted and treated with sulphate of ammonia—kept it closely cut, and to-day it is a wonderful and beautiful homogeneous piece of turf, and at the present moment it represents my ideal for a green.

I quote from Sir Robert Greig's letter in reply:—

> "Many thanks for the plugs of the grasses. I am very much interested in them, and I have placed them out in my garden so that I may watch them next summer. I have also read your article, and I am convinced that there is much in the vegetative method. It stands to reason that we should get much better results here from samples of our best greens or best fairways than from imported American stock. If we could only get a really good experimental station going, we should soon settle such points as you have so carefully worked out with regard to Agrostis Canina. I have seen the vegetative method worked in Canada with splendid results, and when we have really discovered what are the best grasses for our purpose there will be no difficulty in multiplying them to any extent by the vegetative method. I would like to find *a grass that would make a really good tee*. The finer grasses do not seem to stand the wear and tear sufficiently, but I imagine that a properly made and well-manured tee started by the vegetative method would probably stand better than one which had been seeded or had been laid with turf. All these things ought to be worked out."

Is one not now justified in submitting that there is a *complete case for conducting experiments in vegetative propagation by the stolon nursery method?* Particularly does this apply to Agrostis Canina—it is an extremely shy seeder, and I believe pure seed cannot be obtained at all; certainly after many enquiries I cannot find any seed firm, large or small, that has even a few pounds. I have just received a pound from Canada, and it will be interesting to test its germination percentage, and more so to see what sort of grass may come up, as the botanical nomenclatures of the various grasses have not yet been completely standardised as between the two Continents.

Let no greenkeeper begin such experiments with our English Agrostis Alba, which, though exceedingly stoloniferous, is comparatively a coarse grass. A favourite habitat for this grass is an old quarry, and I have seen it growing in the sand bunkers of many clubs. A good strain of Agrostis Vulgaris is certainly well worth trying out; in fact, it may yet prove that the best turf from a wearing point of view should comprise a certain proportion of this grass along with the Agrostis Canina—my reason for hazarding this being that it is just possible that the latter by itself might be almost too velvety. But where any greenkeeper has noticed patches of Agrostis Canina on his links, *I would ask the Green Committee* of any such club—both in their own interest, and as a contribution to the common stock—to encourage him to experiment.

Should any secretary or greenkeeper desire confirmation of any grass that he suspects as being Agrostis Canina, I should be happy to give him my opinion on the same; in such case, please post to the writer, c/o " Golfing."

I do not think we can expect the seedsmen to take the lead in this work. One recognises that it is their business to sell seed; but should a demand arise for stolons, one has little doubt that they would ultimately respond and cater for it in competition with the price that any club that so minded could produce them at for itself.

A New Tested Practice for Weed Control,

By NORMAN HACKETT.

PREVIOUS articles on this problem have dealt almost exclusively with the use of sulphate of ammonia, both by itself and mixed with compost, thus supplying the necessary plant food—nitrogen in particular; and concurrently with this treatment the complete omission of lime in any form—sea sand included; thereby creating ultimately an acid condition of the soil, which medium is inimical to clover, weeds, and the coarser grasses, and correspondingly favourable to the finer grasses. These articles have all been based on the American experiments (and used by kind permission of Dr. Oakley, Chairman of the U.S.G.A., Scientific Green Committee), the experiments of Nitram, Ltd., and of those of the writer and other individual workers.

Meanwhile our American friends have not been content to rest on their oars. It must ever be an axiom of all scientific research that finality is unattainable, and the recognition of this fact only serves to enthuse every research worker to unlock yet another door to Nature's secrets.

They have experimented for over five years with a large number of chemical salts, quite apart from fertilisers, to ascertain their marked effect—and it would appear they are now satisfied as to the value of *arsenate of lead*, and I print verbatim two articles from their September and November *Bulletins*.

It will be noted that the arsenate of lead treatment is *supplementary* to the sulphate of ammonia and compost treatment.

ARSENATE OF LEAD AS A BEETLE, WORM, AND WEED ERADICATOR.

By Norman L. Mattice, Manager, Pine Valley Golf Club.

When I entered the employ of the Pine Valley Golf Club last spring, permission was obtained to secure the services of Mr. B. R. Leach, of Riverton, N.J., to act in an advisory capacity to supervise the use and application of arsenate of lead on the tees, fairways, approaches, and greens. This chemical was used for the purpose of exterminating the grub of the Japanese beetle, which had done considerable damage to the turf in former years. As planned, the arsenate of lead was mixed in the topdressing at the rate of 5 *pounds per cubic yard, and spread on* 1,000 *square feet of area.* To date, the tees, approaches, and greens have been topdressed five times, and the fairways once. As a result of carrying out this programme the main object of killing beetle grubs was accomplished before any appreciable damage to the turf occurred, and, in addition, three other beneficial, but unlooked for, results were obtained as follows:—

Many of the greens contained chickweed in large quantities. In one instance, on the old 9th, an effort was made to remove some of the chickweed last year by cutting it out, leaving large patches with no turf, so that the green has not been in play all summer. After the first application of the prepared topdressing it was noticed that many of the patches of chickweed on all of the greens (including the old 9th) turned yellow and disappeared, and the turf came back in its place. After each subsequent topdressing, more chickweed disappeared, until all of the greens are almost entirely free from it, and strong and vigorous turf has taken its place.

During July the beetles began to fly over this part of the country and alight on the greens. They immediately began to burrow down into the soil to deposit their eggs, and, in doing so, little piles resembling worm casts covered the surface of the greens. On closer observation, a full-grown, dead beetle was found in each pile of earth. It seems that the soil had been sufficiently poisoned to kill the mature beetle as well as the grub.

After the second topdressing early in May, worm casts dis appeared entirely from the topdressed area, which would indicate that worms do not take kindly to soil so poisoned.

Although some crab grass appeared in the surface of the tees, approaches, and greens, it did not start to grow until the 1st of August, and then it did not grow vigorously as is its custom. Other unpoisoned areas developed strong thrifty crab grass plants late in June, which have already seeded at the time of this writing (September). Employees who have worked for many years on this course state that crab grass on the tees, approaches, and greens is not one-tenth as bad as it has been in former years. However, the big decrease in the growth of crab grass cannot be attributed wholly to the use of arsenate of lead, for sulphate of ammonia has also been used in every application of topdressing. If the marked effect from the use of arsenate of lead is as great next year as it has been so far this season, it is reasonable to believe that weeds of all kinds will be eliminated from the poisoned area, and a better and more thrifty turf will result.

THE WEED PROBLEM WITH SUGGESTIONS FOR CONTROL.

By B. R. Leach, Riverton, N.J.

The problem of controlling weeds in the fine turf of golf greens is still a source of great annoyance and expense to most golf clubs. Much experimental work has been done during the past few years on this general proposition of weed control, and it is proposed in this article to correllate the main results of these investigations together with certain results obtained in my own experimental work at Riverton, N.J.

(This is one of the turf investigations projects sponsored and financed in part by the United States Golf Association.)

THE SOURCE OF WEEDS.

There are two main sources of weeds as far as their being in greens is concerned. (1) Certain weeds, such as dandelions, have very light seeds, and these are blown on to the green from the surrounding rough and fairway. From the standpoint of weed control alone it pays to mow the rough at frequent intervals, thereby preventing, in a large measure, the ripening of these wind-blown seeds. (2) The second source of weeds is the topsoil used as an ingredient of the topdressing. Topsoil nearly always carries an abundance of weed seeds, and it is the topsoil used in topdressing that is one of the leading sources of weeds in greens.

Weed control methods may be arbitrarily classified under the following headings, although they merge to a certain extent. (1) Weeding by hand. (2) Acid-reacting fertiliser. (3) Composting. (4) Steaming and baking of compost. (5) Arsenate of lead.

HAND WEEDING.

It may be stated as an axiom that, regardless of all the methods employed in controlling weeds, *some hand weeding will be necessary.* This is the case because no method or combination of methods will give 100 *per cent. weed control.* Under the circumstances it would seem advisable to use common sense in the management of hand weeding operations. Unfortunately, most clubs resort to one extensive hand weeding campaign about the height of the crab grass season, and do very little weeding during the rest of the year. This is a fundamental mistake in fine turf management, and can only result in poor and thin turf.

Fine grasses cannot compete with some weeds under the closely-mown condition of the modern golf green. If you study the grass in the immediate vicinity of a weed you will note how *the weed dominates* the situation with its broad leaves, dense growth, and in many cases a tap root of tremendous water and food obtaining capacity. The bigger and broader the weed, the more it drains the vitality of the fine grass in the immediate vicinity.

Under the circumstances, hand weeding should be made an important part of the routine work throughout the growing season. At the beginning of the growing season, particular attention should be paid to this detail of course management.

As a result of this early weeding, the fine grass has its own way, and, provided proper fertilisation and topdressing is practised the turf will be thick and heavy by the time crab grass begins to make its appearance. This thick, heavy turf will be less infested with crab grass, because the soil surface is already crowded with fine grass, and the crab grass has more difficulty in getting established.

Ordinary observation will prove the truth of this statement. Examine a green at crab grass time, and you will note that the crab grass is thickest where the fine turf is thinnest. The moral, therefore, is to spend the time and money throughout the season prior to crab grass time in weeding, fertilising, topdressing, etc., with the object of thickening up the turf to withstand the crab grass invasion.

It is better to spend money in the above way than to waste it in digging out masses of crab grass in August, leaving the green looking badly and in poor playing condition. A green thus cleared of crab grass is a thin and sorry sight, but it is a sorrier job to thicken it up at that time of the year when growth is naturally beginning to slow up. In fact, it is an impossible job. If you want a nice Poa annua green this is the easiest way to get it.

FERTILISERS.

From the standpoint of weed control fertilisers, particularly acid-reacting fertilisers such as ammonium sulphate and ammonium phosphate, are valuable for two reasons. (1) They cause the soil to gradually become acid in nature, thereby creating a soil condition unfavourable for the growth of many (but not all) weeds. (2) They stimulate the growth of the fine turf grasses, and create a thick heavy, and luxuriant turf, in which weeds have a greater difficulty in gaining a foothold. From both these angles proper fertilisation is of the utmost importance in weed control. Irregular fertiliser applications mean that you are giving the weeds the edge. Fine turf cannot prosper without this feeding, but weeds can and do.

WATERING.

Careless and indifferent watering gives weeds the edge because most of them are deeper rooted than the fine turf, and can withstand drier soil-surface conditions.

THE TREATMENT OF TOPDRESSING COMPOST.

In view of the fact that the topdressing is such a fertile source of weed seeds there have of late been many advocates of the treatment of compost in such a way that these weed seeds will be killed before it is applied to the green.

Allowing the ingredients of the compost pile to rot for a year or more before using, in addition to making the ingredients more desirable for topdressing, also *results in the death of many short-lived weed seeds*, but it does not kill many of those weed seeds possessing hard coats.

STEAMING THE COMPOST.

Several articles have appeared in *The Bulletin* within the past year describing methods of treating topdressing material with steam for the purpose of killing weed seeds as well as toning up the compost so treated. Steaming is a very efficacious method of so treating compost. Unfortunately, it is an expensive method, inasmuch as the apparatus is costly, and the labour and time involved is considerable. Furthermore, it is quite possible to oversteam soil, thereby devitalising it for long periods of time. From the standpoint of the average greenkeeper I doubt if steaming will ever become a very popular method in modern greenkeeping practice.

RELATIVE VALUE OF TOPDRESSING TREATMENT FOR WEED SEED CONTROL.

Steaming or similar treatment (properly given) will kill most of the weed seeds in topdressing so treated and to that extent it is of value. Nevertheless the consistent treatment of all topdressing in this way, while it will aid to a certain extent in keeping the green free from weeds, will not solve the weed problem entirely since topdressing is after all only one source of weed seeds. We still have wind and water borne weed seeds to contend with, thereby necessitating hand weeding. Experience only will determine the value of topdressing sterilisation for the individual golf club.

ARSENATE OF LEAD AS A WEED CONTROL.

Five years of experimental work have shown the value of this chemical as a control for grubs and worms, and incidentally as a weed control in fine turf. It is being used in greater quantities each year. Those interested are referred to the article in the February, 1927, number of *The Bulletin* for detailed instructions regarding the use of this material.

The experimental plots at Riverton are at this writing a source of very interesting study. Plots poisoned with arsenate of lead at the rate of 35 *pounds per 1,000 square feet of turf at the time of planting the stolons are practically free of crab grass and other weeds.* Plots not so treated, but topdressed with poisoned soil for two seasons show decided weed control; while plots which have received no arsenate of lead contain crab grass and other weeds in abundance.

The value of arsenate of lead as a weed control agent is due to the fact that not many plants will grow in soil containing the chemical The majority of weeds common to fine turf succumb to the poison, and, in fact, many weed seeds fail to germinate in soil so treated. The fine turf grasses, on the contrary, seem to be stimulated in their growth by the arsenate of lead. From the standpoint of grub, worm, and weed control, the use of arsenate of lead would seem to be the easiest and cheapest method for the modern golf course. It is suggested that it be given a trial by those clubs having problems of this nature to cope with.

CONCLUSIONS.

Weed throughout the season, making it an important part of the routine work. Thicken up the turf by proper fertilisation, topdressing and watering before the beginning of the crab grass season. The weed problem can be lessened to a certain extent by steaming or some similar treatment. Give arsenate of lead a fair trial as a means of controlling grubs, worms, and weeds.

The last page of the month's American *Bulletin* is always not only interesting, but amusing, and, moreover, serves a very useful purpose. The more serious and exacting work being accomplished, one can imagine the editors as they relax and ask each other, " What is to be the tag this month to get it home to those ignorant blighters who think us and our work no darned use? " Their November effort I consider particularly bright, anticipating and silencing as it does the criticism of those people who are for ever content to go on with the old way; although these same people cannot help but acknowledge the benefits that are every day accruing from scientific research, yet they have never been able to bring themselves to realise that good greenkeeping is more of a science than an art, and must be so treated and pursued.

Here is their November tag.

AS WE FIND THEM.

Heard one greenkeeper say, " This modern scientific stuff is the bunk, and I'll have nothing to do with it. Didn't I take care of a good golf course years before there was any scientific greenkeeping? They can't tell me anything about running greens."

A fellow greenkeeper promptly answered, " I suppose if you were Noah returning to this world to-day, you would say, ' This modern scientific navigation is just fairy-tale stuff. Didn't I take a successful cruise years before science cluttered up ships with steam, oil, electricity, radio, and all that other trash?. They can't tell me anything about running big boats.' "

Another guardian of the greens told me he didn't regard ammonium sulphate as a fertiliser, and therefore had decided to quit using it. Someone had told him the only thing worth while in ammonium sulphate was the nitrogen. Someone else told him nitrogen was a gas, and the air was full of it. Promptly he put two and two together to make sixteen, and concluded, " a gas can't be a fertiliser; therefore, ammonium sulphate is not a fertiliser."

Let's hope that no one tells that fellow that nitrogen is one of the chief components of human foods (proteins). Such a theorist might decide to economise, and depend on the air for his personal nitrogen supply. It surely would cut down his living expenses, for he could then give up all meats, fish, eggs, milk, beans, peas, and the like.

Still another admitted earthworms were exceptionally numerous on his greens. He knew he could get rid of them, but Nature put them there and they must have some purpose. "I am not going to interfere with Nature." But wait till the club members get wise to that sweet sentiment. May we hope Nature never sends that greenkeeper one of her masterpiece donations—a human tapeworm.

One keeper of the greens remarked, " This fuss about different grasses and different strains of grasses is just some of that scientific tommy-rot. They can talk about grass strains all they want to, but, after all, ' grass is grass.' "

How true that is! Likewise, "A car is a car," though there be Fords and Packards, trolley cars and kiddie cars.

The Weed Problem Again,

By NORMAN HACKETT.

FIRST of all, let me refer to two points in my last article which have exercised my own mind, and doubtless have puzzled some readers.

The figures there given as to the rate of arsenate of lead mixed in the topdressing, and the spread covering area are as in the

American *Bulletin*—there is no error or misprint on that score—but, nevertheless, there seems to be room for query. This was the rate given:—" The arsenate of lead was mixed in the topdressing at the rate of 5 *lbs. to the cubic yard, and spread on* 1,000 *square feet of green.*" Now a *single* dressing of a cubic yard (equals one ton) to 1,000 square feet of area is obviously wrong—the usual rate is a cubic yard to 5,000 square feet. Now, since the article proceeds:—"To date, the tees, approaches, and greens have been topdressed five times "—one is tempted to infer that the cubic yard was spread in *five* (monthly) applications.

In regard to the other point—where the *soil itself* was poisoned before stolon planting or seeding at the rate of 35 lbs. per 1,000 square feet of area, I see no reason to query this, as the 35 lbs. would be mixed and incorporated with the top three inches of soil, and three inches over an area of 1,000 square feet is equal to nine cubic yards—so that here there is about 4 lbs. of arsenate of lead to every cubic yard, which it will be noted almost corresponds to the 5 lbs. per cubic yard when applied as a topdressing; but still the first query as to area or number of applications remains, and I am writing Dr. Oakley in regard to it, and trust next month to be able to give the explanation.

Dr. C. M. Murray, D.S.O., of Cape Town, has recently sent me a contribution, which is very apt, Readers may be interested to experiment with the two systems on at least experimental plots—the writer certainly intends to do so.

CHEMICAL WEED ERADICATION.

By Dr. C. M. Murray, D.S.O., Cape Town, South Africa.

Though the recognition of the value of soil acidity in the maintenance of turf has led to a considerable diminution of the amount of weed to be dealt with in putting greens, there will still be an annual invasion to be coped with. The main source of this invasion is doubtedly wind-borne seed. The summer air becomes charged with myriads of seeds, which are steadily deposited over the surface of the turf.

Topdressings have always been blamed for the introduction of weeds. With a view to avoid this source of infection we have carried out experiments with heat sterilised topdressings. Very little, if any, difference was noticeable. The small amount of weed seed in well prepared topdressing must be fractional compared to the mass deposited from the air. What the topdressing undoubtedly does is to supply a germinating bed for the seeds already there.

The problem then is how to combat this annual invasion. Hand weeding is slow, laborious, disturbing to the play, and very expensive. The preparations sold under the title of " lawn sand," which depend for their action on the various hydroscopic salts used were a step in the right direction. But as the importance of the acidity factor was not known, it is more than probable that alkaline salts were used, thus rendering the ultimate results sufficiently unsatisfactory to prevent their universal adoption.

It was to overcome these difficulties that led us to adopt the suggestion of a chemist to use sulphate of iron in combination with sulphate of ammonia. The advantage of this mixture is that both these salts are acid-reacting. In 1910 we commenced experiments with this mixture on a small scale. By 1914 we had achieved very gratifying results, when our researches were brought to an end by the Great War.

After the war we resumed with a mixture of 75 per cent. of sulphate of iron and 15 per cent. of sulphate of ammonia. The two salts are melted, and 10 per cent. of sand added to prevent re-crystallisation. The resulting cake is easily crushed to a fine powder.

This powder is highly hydroscopic. When dusted over the green on a bright sunny morning, just as the dew is beginning to dry off, the powder sticks to the herbage. The weed leaves present a larger surface, and retain the moisture longer than the narrow blades of the grass, and so receive the bulk of the powder.

As the dew dries away, the weeds, which have thin, porous skins and a high water content, absorb the hydroscopic salts, and in the course of a few days turn black and shrivel up. The grass blades are coated with a hard, shiny skin, due to the deposition of silica salts, and also have a relatively low water content. For these reasons, in the first place, it is difficult for the powder to adhere and, secondly, even if it does the low water content makes their absorption less easy. Unless an extremely heavy dose is applied, the grass, therefore, escapes uninjured.

This preparation may be *applied at the rate of* 25 *to* 100 *lbs. to a green of* 800 *square yards*. Even under our fierce summer sun the maximum dose produces very little scalding of the turf. If a particularly hot spell follows the application, the process may be stopped at any stage by a liberal soaking with the sprinklers.

This method has been used by us with increasing confidence for the past seven years, whilst for the past four years we have used it entirely for the eradication of weed on all our greens and tees, and as far as we could afford it on our fairways.

A point of interest is that the sulphate of iron appears to have a decidedly beneficial effect on the turf, rendering it finer, sturdier, and of better colour than when sulphate of ammonia alone is used.

The method provides a means of eradicating weed with speed and precision, and at a fraction of the cost of hand weeding. It does not disturb the play, is thorough, and in the end provides a splendid stimulant for the turf.

To my mind the only practical difficulty in this treatment is the *melting* together of the two salts. When I first received and read Dr. Murray's letter I wondered whether he really meant "melt" or dissolving the two together—adding the sand—and then let the moisture evaporate. I, therefore, submitted the question to Mr.

H. J. Page, Head of the Research Laboratories of Messrs. Nitram, Ltd., who very kindly replied as follows:—

"I think that Dr. C. M. Murray, when he uses the word 'melted,' does actually refer to the fusion of the salts. Iron sulphate is a salt which contains seven molecules of water of crystallisation in its molecule, and, on heating to quite a moderate temperature, it melts to liquid, which is actually a strong solution of iron sulphate in the water of crystallisation originally present. In order to avoid too high a temperature, under which circumstances the added sulphate of ammonia would be liable to be driven off, the best way to prepare the mixture would be to *heat the iron sulphate first of all in a large metal pot or basin*, using only sufficient heat to convert it completely to a clear liquid. The necessary quantity of sulphate of ammonia should then be added, the temperature being again only sufficiently high to allow the whole mixture of this sulphate of ammonia to dissolve in the liquid. If the necessary amount of sand is now added, and the whole mixture is kept thoroughly well stirred while cooling, until it sets, a product will be obtained which can be readily powdered up to a fine condition suitable for application to the lawn. The resulting compound does not consist wholly of the double salt, iron ammonium sulphate, since the proportion of iron sulphate in the mixture is much higher than that required for the formation of this compound. The mixture actually consists of iron ammonium sulphate mixed with the excess of iron sulphate."

It is, therefore, apparent that the operation of preparing the fused mixture will entail a little trouble and expense. To make even 25lbs. to 50 lbs. a fairly large iron receptacle and a fire will be necessary; but if the treatment is proved to be an established success a larger iron cistern on a brick foundation, with space for fire, should meet the case.

The use and benefit of sulphate of iron by itself, and also *mixed* with sulphate of ammonia, has long been known to some greenkeepers; but it is quite likely that the much more intense hygroscopic action of the melted or fused salts will prove more advantageous.

An Evening with the Greenkeepers' Association.

By NORMAN HACKETT.

A FEW days ago I had the pleasure of meeting, in London, members of the Southern Section of the Greenkeepers' Association—to the number of about fifty—at the London Stone Hotel. I had been asked to lecture, but felt that more good might accrue if we took in turn different problems and practices of greenkeeping, and then had a general discussion on each. I was specially interested in the fact that no member voiced any disagreement with soil acidity theories, but that on the other hand several subscribed to them as the result of their observation and experience.

Some of those present had the idea that it was the nitrogen alone in sulphate of ammonia that did the trick—whereas, of course, the actual acidity is caused by the sulphate part of the salt after it has given up its nitrogen. It is vital to keep this fact in mind, for, on the other hand, when nitrate of soda has given up its nitrogen it leaves an alkaline base in the soil, exactly the opposite effect to that of sulphate of ammonia. Another point that cannot be too strongly emphasised is that no lime in any form must be used with sulphate of ammonia, or the whole effort to establish acidity will be nullified.

Lime plus sulphate of ammonia will encourage the coarser grasses. Sulphate of ammonia with no lime provides a soil medium more favourable to the finer grasses, and, moreover, you will see no increase in the spread of these finer grasses until the soil has become definitely acid. If lime, sea-sand, or alkaline fertilisers have been used in the past it will take two or three years' treatment with sulphate of ammonia before the soil will pass through the neutral point of P.H. 6.9, into definite and increasing acidity.

I was pleased to hear that a good many members had purchased the *Soil Testing Outfit*, previously mentioned. For the benefit of those newly interested, I give the name of the firm and the address where the same can be obtained: The British Drug Houses, Ltd., Graham Street, City Road, London, N.1. Where, however, a more exact determination of soil acidity is required, it will be necessary to get their more elaborate outfit, as used by the medical profession; but this is only necessary and interesting as enabling one to test a given soil periodically, and note the gradual decimal declension in P.H. values. But here I will stop. We have hardly introduced decimal points into greenkeeping as yet, and some readers may deride me as being too scientific to be practical, and yet in all research the two must go hand in hand; one has only to mention the words " artificial silk " to bring this home.

Nor did any of my greenkeeper friends at this meeting level such a criticism at me—though it is more than possible they may have thought it, and no doubt would have done so if I had not taken the precaution of bringing with me several sample turves from plots produced in our Keighley experimental nursery, under acid soil conditions and fertiliser treatment. One turf that evoked unstinted admiration was composed of pure Agrostis Canina from a bed kept and cut under green conditions, and I am still of the opinion that this almost seedless grass would by itself make the most perfect greens, as soon as we have definitely and practically determined that we can propagate it by the stoloniferous method. The question was asked how it would wear. There can surely be no doubt about this, in spite of its velvety nature—it is a "bent," and the bents are among the hardiest of the grasses—and the only reservation I would make on that score would be that it might prove that a certain proportion of its sister bent, Agrostis Vulgaris, was advisable.

One thing we all whole-heartedly—and I might say sorrowfully—agreed upon, and that is the heritage left to the poor greenkeeper by some constructional contractors. I know from personal observation of many reconstructed and new greens where it would seem that no care was taken to *put back the original top soil* before turving or sowing—in many cases I have found *clay directly under the sod.* Where this has obtained it is impossible to expect any greenkeeper to grow good turf. Moss and Poa annua will invade such a green, and no amount of fertilisers, artificial or otherwise, will eradicate them; in desperation, palliatives, such as sand and charcoal will be spread on the turf, but while these will make the sod itself more porous and help a little, they will not *penetrate the clay.* During constructional work the club's greenkeeper is often reduced to the position of a "lad about," as we say in Yorkshire—I don't say designedly, but in effect. The club committee consult with the architect, and attach full responsibility to him; he in his turn is dependent on the contractor, with the result that in numerous instances this divided responsibility has subsequently thrown an anxious burden on the club greenkeeper, which he can never remove. When such work is in progress, I cannot too strongly urge club committees to see for themselves that the top soil is put back, and, further, when the top soil is at all of a clayey nature, that sand or fine ashes are incorporated with it to give the desired porosity, and that humus is forked into the top two or three inches. The ideal top soil for a putting green requires to be as carefully prepared as that *prepared by a gardener in his potting shed* for his greenhouse, and should contain similar proportions of loam, sand, and humus.

It is hardly necessary to mention that an adequate drainage system must be constructed just below the level of the top soil. *Drainage and porosity* is an absolute sine qua non for the production of good turf, and unless this obtains the application of all fertilisers is useless.

Two or three members asked me what was the cause of, and cure for, "autumn rust.' I had to acknowledge that I was not au fait with this disease, unless it was a name given to the brown effect caused by the old blades of Poa annua dying, but I was assured that this "rusting" of the tips of the blades applied to the fescues. On playing round my own course the following Saturday, I kept my eyes open for any such effect. I could not discover a trace on any of our greens, but on several fairways it was discernible. After my round, I went out to make a more minute examination, and discovered that the blades so rusted were in most cases Poa annua and probably also Poa pratensis, Poa trivialis (smooth and rough-stalked meadow grass, respectively) and possibly crested dog's tail (it is very difficult to distinguish between these latter three grasses at this time of the year), but I satisfied myself that the fescues and bents were absolutely immune. It would appear that this does not apply to other courses and conditions, but I am writing to one of the members asking him to verify that his grasses affected are indeed fescues.

There still appears to be some apprehension, if not prejudice, against the use of perchloride of mercury as a worm killer. Amongst greenkeepers, I have only met two who considered that its continued use had a detrimental effect on the turf, and in both cases the inference was supposition. The greens had gone off one particular year, and the cause was assigned to perchloride. I quite agree that, owing to this salt being such a virulent poison to animal and human life, the cumulative effect of its use is quite naturally open to suspicion. In this connection, I recently noticed a paragraph in a paper on bowling green treatment, the writer discountenancing the use of perchloride as "being such a strong poison, it must be injurious to the tender roots of the finer grasses." The theory is quite plausible, but in my opinion other considerations and definite experience nullify it.

In the first place, what is the strength of the solution applied? The maximum is 3 ounces to 50 gallons of water, which is 3 *parts in* 8,000, or .04 per cent. Now, although perchloride is a poison, it is used in medicine for a certain disease, and a dose is one-sixteenth of a grain in a drachm of water; this percentage works out at one part in 960 or nearly three times the strength of that employed in worm killing; and again, medically, it is used externally as an aseptic at exactly the worm-killing strength. Incidentally in this connection it may be observed that it is a protection to greenkeepers against tetanus (lockjaw), or, indeed, any festering of a cut or sore. Then one must also remember that, because a substance acts as a poison to human and animal life, it is not necessarily poisonous to plant life. Many plants and berries contains poisons themselves, and, indeed, thrive on the natural process of their formation.

At the Arlington Research Station, U.S.A., they have tried out perchloride of mercury thoroughly, applying it continuously for seven years, on turf plots, and no difference is discernible as between these plots and others fertilised and treated exactly the same in all other respects, but with a non-poisonous worm-killer.

Moreover, in America, they are now using perchloride in comparatively large quantities—incorporating it with top soil so as to render it toxic to worms and grubs, and as a specific against "brown patch," a bacterial disease that is very common over there, and not unknown in this country.

It is not generally known that this worm-killing property of perchloride of mercury is not really due to its poisonus nature per se, but to the fact that it is an extreme irritant to delicate animal issues. A worm's skin is exceedingly tender and sensitive, and Nature has provided for this weakness by endowing it with the power to secrete a slimy covering for its protection in its normal life and functioning, but which is not proof against an abnormal irritant. What really happens is that the worms come to the surface in order to try and escape the irritation, and then die, *not from being internally poisoned*, but from what amounts to shock.

All worm-killers depend for their action on this property of irritation; most acids and alkalies, for instance, are effective, but in most cases their use would be injurious to the turf.

Some General Hints.

An Address delivered by Mr. NORMAN HACKETT to the Western District of the Scottish Golf Union.

THE CHAIRMAN (Mr. George Bryce): Gentlemen, I feel an apology is due from the chair, owing to the fact that there is no room for all the gentlemen who wish to be seated. But, as we had only 160 acceptances, and this room is supposed to accommodate 255, it seems to me that there are at least 250 gentlemen present, whom I am very pleased to see, and I hope you will put up with the inconvenience.

If I were asked to choose a slogan for the Scottish Golf Union I should select that beautiful device which appears on the escutcheon of H.R.H. The Prince of Wales, which represents " service." The initial purpose for which the Scottish Golf Union was formed was that of service to its clubs, and since its inception it has done a deal of spadework, with the result that where in certain directions there was chaos, there is to-day a considerable amount of uniformity of method. It is felt, however, that the activities of the Scottish Golf Union might profitably to its clubs, be extended. It is just possible that the Golf Unions of Great Britain and Ireland may be consulted by the Joint Advisory Committee on this very big question of the maintenance of golf courses. The western district, your district, has had this matter under review for some time, and it was thought well that we should be prepared when the day came, if it did come, for a decision on this point—a reason decision. We desire to put before you as full information as possible, and for that purpose we ask our lecturer, to-night, if he could come and help us. I know something of what Mr. Hackett has to say to you to-night, having sat up with him until the wee sma' hours of the morning, but one thing I can tell you—Mr. Hackett very kindly and promptly agreed to be with us this evening, but he did not come from Yorkshire to Scotland to tell you something you already know. I feel that what Mr. Hackett is going to say to us this evening, and what he shall say to the Lothian district in Edinburgh on Monday, will have a tremendous influence on the decision at which the Scottish Golf Union shall arrive on this question of intense interest to every club. Mr. Hackett is an amateur. As such he appeals to me tremendously. He has no axe to grind; he has nothing to sell. With the hearty acquiescence of his club committee he has conducted a good deal of research work at the Keighley Golf Club—installing there a nursery of grass plots, and he has arrived at conclusions which he proposes to place before you this evening. Possibly unknown to Mr. Hackett, Mr. Hackett is not unknown to many of us, who have followed with intense interest his articles; articles gratuitously contributed to a golfing journal. These articles have given many of us to think, and to think deeply. I will not delay further, because I know how I felt the first time I read his first article. There is just one point that I would suggest—I have little more to say. In our district, the western district, we have very excellent greenkeepers. I am glad to recognise many of them this evening. These are conscientious men, who know the practical side of the work inside out. I am not just so certain that they are as well supported as they deserve. My contention is that a good greenkeeper deserves a good convenor. I am afraid this question of the convenor of the green committee is one which has not been taken quite so seriously as it deserves. According to the custom in our district, the constitution of most of our clubs states that members of committee serve for a period of three years, and are not eligible for re-election. I grant you it is possible to co-opt a man for a year, and the wise club does so. I, therefore, throw out the suggestion to you that when you get a good green convenor, I tell you what to do with him—I would sentence him to ten years' hard labour. He deserves it.

I have very much pleasure, gentlemen, in introducing to you Mr. Norman Hackett.

Mr. Hackett has just told me that it is his desire that when he has finished telling you what he has to say—his fund of knowledge is wonderful, and it is quite impossible for him to remember 25 per cent. of what he knows—by way of questions, you should extort the remaining 75 per cent. from him.

Mr. Norman Hackett:

Gentlemen, you must not believe all the very kind things that Mr. Bryce has said about me. I can assure you that I look forward to coming to meet you to-night, and when I say that I don't want you to think that I am coming here with the idea of being dogmatic or trying to teach you a lot of things. I think probably you will be able to teach me as much as I will be able to teach you.

My experience with greenkeeping problems is that the whole trouble lies in the fact that we know so little about them. Very little research work has been done, and, therefore, I just want to tell you what I have learned, and what perhaps has come to me from readings and from individual research. At the same time, I don't want you to think that I pose as an authority, because I have found in this science, as in all sciences, that the more one learns the more one realises how little one really knows. Mr. Bryce has very kindly referred to the fact that it is a hobby of mine, and that my interest in this is disinterested. That is so. I don't make a boast of it, but I am rather glad he mentioned it. You will know that if I recommend a thing, or if I damn it, I do so because I get no commission from anybody. In this connection I might tell you that the very first article I wrote for "Golfing," about three or four years ago and that was before I tried my hand at research work. I was much surprised when I received from the editor a cheque for £3 3s. I decided there and then that any interest I had in this should not be financial, and I promptly sent that cheque back to the editor, and told him of my determination. I may say that it pained me exceedingly to do this, for both the proprietor and the editor are Scotsmen.

Believe me, there is no wizardry about fertilisation. To those who understand the science, the chemical side of it only; it is known that certain substances will act as fertilisers, and it is no good paying through the nose when one can make them up just as easily. In that respect a Scientific Research Station, when established in Great Britain will be of immense service to clubs, not only in that direction, but in every way. The whole field of research will be duly covered.

In speaking to you, you must remember that you, in Scotland, were educated at least one or two generations before we were in England, and, therefore, you are more up to date. A good many greenkeepers, however, look askance at scientific research, and they think that because a man maybe knows his chemistry and the scientific side of the business, he is not therefore a practical man, I certainly do try to combine the two, for I had a scientific education—I may say I am in the leather trade, and I have my own chemical laboratory. I am, however, interested in the practical side of research, and have been for a good many years, so that I can speak on both sides of the question.

I propose just to divide what I have to say to you under different heading, and as I finish with each heading I will be very glad if you will ask questions on each subject before we go on to the next. I think in that way we shall get a better idea of each subject. And now the first thing I am going to talk to you about is what I might call the new Acid Theory in regard to soil for greens especially. As you know, in this country, from time immemorial, we have really been in the hands of the agricultural scientists, and they have told us that in order to produce a good crop of grass we must use lime. That is perfectly right from the point of view of getting a hay crop. You know that for a hay crop you want coarse grasses that grow tall, and provide the biggest weight of hay, such as cocksfoot, timothy, crested dogstail, smooth and rough-stalked meadow grass; but we don't want those on our greens, and lime encourages them. In order to achieve a soil more favourable for the finer grasses, and to discourage the coarser grasses, then we must omit lime. The Americans were the first to find this out. They have had a Scientific Green Committee since 1921, and even before that date they were experimenting. In 1921 they formed a research station with two very prominent agrostologists at the head, and they have their Research Station at Arlington, where to-day they have over 1,000 different turf plots. All have been fertilised, or manured, or worm-killed, or treated in different ways. Everything is done in duplicate. They also have check plots. Some plots are from seeds others propagated from stolons, and fertilised in multifarious number of ways. When they get down to the bottom of things and work out lines of research and put them into effect, you are bound to take notice of what they have done. You all know that in every trade in this country to-day the present result has not been attained without really hard scientific research. Take artificial silk. You all know what has happened in that trade—it could not have been done without the aid of the chemist. In our special line of golf greenkeeping I think you will all agree that nothing has ever been done. We have simply hung on to the tails of the agricultural chemists, and not with the best results to golf. We don't want the coarser and more weedy grass, but the finer one. To my mind the Americans have proved conclusively that the bents, Vulgaris and Canina, South German bent and American Rhode Island, thrive best in an acid soil. Don't run away with the idea that the soil is acid to the point of corrosion. Believe me, the degree of acidity you require in your soil only corresponds to the acidity of one's perspiration. If you have had a good day's sweating, and you licked your hand, you would not taste the acid effect. The term is merely comparative.

To get a soil acid you have to use an acid-reacting fertiliser. I don't want to go into the chemical side of the question, but when we talk of an acid-reacting fertiliser we mean one that, when it has given up its nitrogen to the growing plants, leaves a certain acid residue. For example, sulphate of ammonia. Phosphate of ammonia is equally as good, but it is more expensive. When we talk of an alkaline re-acting fertiliser such as nitrate of soda, we mean one which, when it has given up its nitrogen to the growing plant. leaves an alkaline residue. Basic slag and calcium phosphate both leave an alkaline residue in the soil. The Americans claim that while, as you all know, a certain amount of phosphorus and a certain amount of potash are both necessary in the soil for the fertility and growth of the plant, you must be very careful to watch and not give too much, or you will immediately create a soil favourable to the coarser grasses. Their practical formula is composting the soil, not in the winter months when the grass is not growing, but beginning from March and April, and going right on until September. Such composts should be composed of roughly 80 parts of friable loom—if you have clayey soil, mix quarry sand (not sea sand) to make a good friable loam—with 20 parts well-rotted manure. If you have leaf-mould, dispense with manure; this is to act as humus. Even the best of scientists vary as to the exact function of humus. Humus serves as a propagating ground for the bacteria in the soil, and without these bacteria it is impossible to make any fertiliser act as a food plant. In a square inch of soil there are millions of bacteria, and if you were to sterilise these and get them out you would not get fertilisation. Humus is necessary as a breeding ground for the bacteria, which utilise and take up the ammonia and oxidise it, and make it available for plant food. For every ton of compost, which is roughly a cubic yard, 15 lbs of sulphate of ammonia should be mixed together, and this is sufficient for 5,000 square feet of ground, or about 550 square yards. For a green of 800 yards you would require about 1½ tons of this compost—that is covering of 1/16th of an inch for a dressing. If this is spread on with the back of the rake it does not affect playing at all. It is recommended to be done every month during the growing season, and this is mainly because the plant should have its food while growing.

With regard to the bents, which to my mind are the grasses we wish to cultivate to the exclusion of other grasses, they break away sending out a shoot from the stem, thus making another growth, so that with composting during the growing months they are more inclined to spread than during the winter. The Americans found that, doing so, composting in four years they raised their greens two inches, and the grasses are not living on the roots of ancestors, but on the fresh soil which is being created every year by using a compost which is ideal. You all know that when you have had constructional work done on the course the work of putting back the top soil is usually very poorly done, and the poor greenkeeper is left with the job afterwards—usually a very hard one. I think you will all agree that the ideal top soil for golf greens is exactly the same mixture as a gardener would use in his potting shed, namely, loam, leaf mould, and sand. You have there a mixture that is absolutely porous, which is, in the main, essential, because all vegetable growths do not want water as water. They want moist air. Three years ago I was an apostle of liming. I depended for information on the usual means, namely, from agricultural books, and when I first studied this acid theory I simply thought they were completely off their heads. When I went into it I began to sit up and take notice. Where I live in Yorkshire a good many of the courses are moorland courses, and I found, on going over these, that while on the "pretties" and the rough we had beautiful red fescue and the bents in abundance, on the greens there were hardly any traces of these grasses, but instead there was mostly Poa annua; whereas there were no traces of Poa annua on the "pretties." Then I tested the soil of both the greens and the "pretties." The "pretties" and the rough not fertilised were acid, and the greens neutral to alkaline. I may say that I have tested so many soils within the last eighteen months that I can almost tell from the nature of the grass the degree of acidity or alkalinity of the soil underneath. I have learned to diagnose the condition of the soil in much the same way as a doctor diagnoses an illness. It is now more or less clear to my mind that the Americans are correct in their theories and practices. Some people say that what may be all right for America will not do for us here. That may be so, but I do not think so. I have had several different American grasses, both in seed and in stolon, and I find I can grow them in Yorkshire, and they grow perfectly well. I am certain we have much better grasses here than they have in America, and if we can only set up research in this country on similar lines I am sure we shall make very great strides in the profession to which most of you belong.

Glasgow Gailes: What continual treatment would you suggest for a seaside green (apart from the question of chemical manuring), and would that treatment only apply to a seaside green?

Mr. Hackett: I don't think that makes any difference. I have been playing to-day on Prestwick, and the grass on most of the greens is "Agrostis Vulgaris." There is some red fescue. I don't think that you can have a better grass, unless "Agrostis Canina," and the treatment I mentioned is the very best for Agrostis Vulgaris. Is Prestwick illustrative of the flora of seaside greens?—Yes.

Question: Would applying one-sixteenth inch dressing in the summer alter the whole aspect of our greens, and make a seaside course pretty much like an inland course?

Mr. Hackett: You mean to say that there would be too much earth. I don't think so, but my idea is that you should find out the best compost for your top soil, and that should apply to both inland and to seaside courses. I made particular point of the fact that in your compost 80 parts must be of a very friable nature. Thus if you have a clayey soil so much more sand must be used. If you have a sandy soil put a little more earth in order to make it loamy. There is no reason why you should not make the 80 parts of a consistency to fit your particular locality. If you make 40 or 50 parts loam, and the other parts sand, I don't think you are going to make your greens at all of an inland nature. I think you will find it easy to make the consistency right. If you have an absolutely sandy soil you would, yourself, put more loam into the compost than sand. I did not suggest that you would put 80 parts loam, but you should make the mixture to suit local requirements.

Prestwick: Would a constant application of sulphate of ammonia further reduce lime in a soil already deficient in it?

Mr. Hackett: Yes, it would. When the Americans began composting the soil on their plots four years ago the soil was just under the neutral point, and lime was already deficient. After four years' treatment with seven monthly applications they got the P.H. value down from nearly 7 P.H. to 4 P.H. 0 is very acid, 7 P.H. is neutral, and 8 P.H., 9 P.H., and 10 P.H. degrees of alkalinity. They found that they did not get weed control and the worms not working until they got below a point P.H. 4. That would take 3 to 4 years to arrive at. I don't know whether you noticed it, but in an early number of "Golfing" last year I published a table of some of the American turf plots—showing (1) Fertilisers used; (2) Present degree of acidity; and (3) Resultant stand of grass and weed percentage. The plots composted and fertilised with sulphate of ammonia only were acidified to 3.7 P.H.; they had the best and finest turf, and were practically immune from weeds and coarse grasses.

I know on my course, where we have got acid conditions on the "pretties" where it has not been treated with lime, we have no worms. I cut a piece of the turf out of one of our "pretties" just before I came away. (Exhibiting sample.) This is a sample of Agrostis Canina. I took some portions and put them into a bed and composted them, and got a very nice homogeneous turf. The only trouble with this grass is that it does not seed. We have, however, found out that it is stoloniferous. As for the American creeping bents, which you have all heard about, I do not consider them good grasses, because we have plenty better. This piece of turf composed of American Washington creeping bent which you see here has a mat already. On March 12th last year I got from Professor Finlayson, of Cambridge, two little plants of this grass. I planted these out, and transplanted them several times, finding out that they throw out stolons over a yard long. On August 1st I cut them into pieces two inches long, and strewed them on a bed prepared as if for a seed bed—strewing them dense enough so that ½ inch space was the maximum distance between any stolon pieces and already a turf has formed as you will note from the sod. The Americans also did this with velvet bent last year. I have been on to the seed people to get the seed, but they say they can't. I have suggested propagating by stolons, but we must look to ourselves for that, and I am certain that research on these lines is going to be very profitable to us.

Question: Do I understand that Mr. Hackett is against the use of sea sand on inland greens?

Mr. Hackett: I am, unless you can't get a quarry sand. Sea sand, and I have analysed a good many of them myself, contains up to 30 per cent. of carbonate of lime, and while sea sand is the best for porosity, and without drainage you can't grow grass at all, we are up against the lesser of two evils. I always recommend the use of a good quarry sand if you can, for you would otherwise not get your soil so quickly acid by the use of sulphate of ammonia, whose effect may be neutralised. That is the only reason I have against sea sand. Eliminate the lime from it, and it would be all right. If you can get sea sand that has been blown, it generally has a very low percentage of lime—but its lime content should be determined.

Question: Are we to understand that land sand is better than sea sand for the greens?

Mr. Hackett: Well, I think so. That is all I can tell you.

Pollock: Generally, it is understood in the West of Scotland that moss indicates an acid or sour condition of the soil. Is this so?

Mr. Hackett: Moss can be due to several things. The main cause is wet. I have found it on lots of places where the sub-soil was very wet; even with clay underneath the soil. There has been no top soil in that particular bit. Moss has arisen through the ground having been improperly drained. You can also get moss from poverty of soil.

Reacidity.—I have always given the palm to these American findings. The main agrostologists agree that the Americans are right. I went to Sir John Russell, who is head of the Agricultural Station at Rothamstead, and he said, " I quite agree with you about this, not that we have made direct experiments with regard to grass for finer turf, but more from the discards of experiments we have made in regard to the fertilisation of agricultural pastures." At Rothamstead they have about 20 plots that have been fertilised for 30 years with the same fertiliser, some with sulphate of potash, some with sulphate of ammonia, and all the other fertilisers alone or in combinations, and the plot treated with sulphate of ammonia for 30 years is entirely composed of bent and fescues. From their point of view you must not use sulphate of ammonia alone to get a good hay crop, and it certainly was most instructive to see the different flora and different kind of grasses on each varying plot.

Pollock: We have been able to limit moss by the application of a soil compost of superphosphate of lime.

Mr. Hackett: If moss is due to poverty of the soil, superphosphate of lime might remedy that. But you must remember that superphosphate of lime is neutral, and is not lime. You might very probably get rid of the moss by giving it the fertiliser the soil is short of.

Question: Supposing that a course in the Glasgow area with alkaline reacting agent takes four men to cut the greens during the summer months, starting on an acid system what increase in labour would that mean? Would it not require about six men under the acid system.

Mr. Hackett; There is no excessive growth with the acid treatment. If you are using sulphate of ammonia and lime together, you will get an excessive growth, but not if using sulphate of ammonia alone. It only encourages finer grasses. In regard to the actual time spent in the composting, if you are going to compost every month during the summer you will want an extra man to cope with the composting.

Pollock: I am sorry to ask so many questions, but I am particularly interested in this question of moss. You say that moss is caused by the condition of the soil. I would assume that it was not bad drainage. How can you restore fertility of soil without lime?

Mr. Hackett: You are up against what has hitherto been held to be absolutely necessary, i.e., that sulphate of ammonia is not a fertiliser unless in the presence of lime, but it has been proved that this is not so. Given time, sulphate of ammonia would produce a lovely growth.

They have found out that as some plants prefer an acid soil others prefer an alkaline, so there is the same discrimination in regard to grasses. If you go on to a moorland course you will invariably find an acid soil. At Hopwood Park course, one of the best of the Manchester courses, they have the finest turf of any course in Lancashire, apart from St. Anne's. The turf is nearly all velvet bent, and is all acid, due to the smoke and soot deposit. The same thing applies to several of the Birmingham courses. I may say that the first time I rushed into print was in a letter to "Golfing." Someone had made mention of the acid treatment, and I wrote to the paper saying this was against everything we had been taught, and I believed that it was not correct. I was on the same side as you are. It is simply investigation of facts that has led me to believe otherwise.

Kilmacolm: In your experience, has it not been proved that, if you have a bank of soil all summer, and you put on this top-dressing in winter, made of this soil, are you not encouraging weeds, because the soil is bound to have weeds in it? How can you keep out weeds in the summer months?

Mr. Hackett: In regard to soil, I agree it is very difficult to get soil which does not contain any weed seed. By the continued use of sulphate of ammonia you get down to this certain degree of acidity when you have got a soil which is not favourable to the germination of weeds, and they will not grow in it.

Question: Have not a good many clubs given up the practice of using this compost, as they have discovered that instead of getting a clean green with compost, they get a dirty green with weeds?

Mr. Hackett: Well, they will have to be very careful where they get their compost from. Most of the weeds will not come from the soil you have used. I think, in practice, most come from the manure that is used in composting. When animals chew grass they are bound to swallow some of the seeds, and these are found in the excreta.

Question: In the Glasgow area a great number of greens are of a heavy nature, and have been laid down in the natural state. Would it be futile to put compost on a green of this description without it having been lightened and prepared?

Mr. Hackett: It is the very salvation in your case. You are building up on your top soil. If you can build up your greens two inches in four years, with exactly the right consistency of soil, it is going to be all the better, and you are doing the right thing. You are putting on your ground exactly the right mixture of soil you want. Owing to the fact that the ground is so heavy, and that you have varieties such as Poa annua on the greens, you have not got the proper grass to commence with. As you thus fertilise you will find by a gradual transition the coarser grasses die out, and these finer grasses come in. I am finding that on different portions of our course now. Year by year it changes.

Hamilton: Do daisies thrive in an alkaline soil more than in an acid soil?

Mr. Hackett: From my experience they thrive more in an alkaline soil.

Question: If you have too acid a soil do you get sorrel?

Mr. Hackett: The soil has got to be very acid before you get sorrel. Sorrel generally come on a wet soil.

Hamilton: Should we use sulphate of ammonia on our greens? At the present moment there is sorrel on our greens, that is to say they are acid?

Mr. Hackett: Sorrel is not confined to an acid soil. I should want to diagnose this patient on the spot—after testing the soil.

Question: Would you suggest a dressing of sulphate of ammonia itself on the greens?

Mr. Hackett: Yes, but it is rather dangerous. They say that every greenkeeper must burn a green before using it right. But if you are going to use sulphate of ammonia alone, ½ oz. to a square yard only should be used, and this should be mixed with some earth and watered in immediately after it has been applied. It is most advisable to do this.

Bothwell: Is the soil in your greens not of a peaty nature on the top?

Mr. Hackett: Well, we have almost every kind of soil. We are rather well situated, as we are in a glacial valley, and have got sand, peat, and gravel.

Question: I would like to know if the grass you have here is part of the course and if it comes off the peat part or off the other?

Mr. Hackett: This Agrostis Vugaris is from a gravelly portion, but this Canina is off a peaty portion, which is on a low-lying bed.

Bothwell: I asked this because last summer I found a very beautiful piece of turf on the seashore. I dug it up to see what was underneath, and found that the finest part was of a peaty nature, and I came to the conclusion that it was the acid nature of the peat that had made so fine a turf. Might I say with regard to lime, you find moss growing on lime walls, which is a sure indication that lime has very little to do with moss.

Question: What grasses would you recommend for sowing down a green?

Mr. Hackett: I should recommend South German bent, composed of Agrostis Vulgaris and Agrostis Canina, and would simply add red fescue. Why anybody suggests rye grass in a turf mixture, I don't know. You certainly can't cut rye grass. I put it once to seedman: "Why don't you go right out and recommend the bents for greens and nothing else?" And he said: "If I were to recommend the bents and nothing else, you are going to send bent prices up to 20s. a lb." That is why I say that that we have got one hope by propagating by stolons. My idea of the perfect mixture is Agrostis Vulgaris, Agrostis Canina, with some red fescue. I recommend sowing 3 ozs. to a square yard if you want to get a quick growth of turf in a year.

Prestwick: Do I understand that you would dispense with all artificial manures, such as superphosphate, bone flour, and guano?

Mr. Hackett: Yes, absolutely. I have used guano myself. But in your compost there is naturally sufficient phosphate and potash for the small requirements of these finer grasses. Their prime need is nitrogen, which they get as sulphate of ammonia.

Question: One or two of our greens were inclined to have moss, and we tried ground lime. I said that lime has tendency to create weary ground, and I recommend sulphate of iron crystals. Was I right?

Mr. Hackett: Yes, mixed with sulphate of ammonia, that is very good indeed. You can't do any harm.

Roughly speaking, taking the analogy of ordinary gardening work, the grasses and the plants want nitrogen. If you have clover, peas, or beans, they want phosphorus. If you are dealing with root crops they will need a good deal of sulphate of potash, for potash is necessary. You have no root crops with grass, and so you don't want much potash, and if you use much phosphorus you are encouraging clover. The main need is simply nitrogen. If you are giving potash, you are feeding the tube root weeds—you are feeding dandelions and buttercups. The use of sulphate of ammonia does not give them food, but it creates an acid condition, and provides a soil medium which is more favourably adapted for finer grasses than for the coarser grasses and weeds.

Question: What is the cause and cure for fairy rings on a golf green?

Mr. Hackett: All we know is that it is a fungus growth, but the cure for it I do not know. I should think that sulphate of ammonia and sulphate of iron will help to keep it down.

Question: Will you never get that fungus on an acid condition of soil?

Mr. Hackett: I do not know, since you ask me. There is only one spot on our course which has got a fairy ring, and that spot is not acid, but I am not going to dogmatise and say that you would not find them on an acid soil.

WORMKILLERS.

Mr. Hackett: What do you, in this district, do about worms?

Well, Mr. Hackett, in the Glasgow area there is a mixture got from the Maryhill Chemical Works, which is used for treating worms. I have tried it in Hamilton, and I find that the worms are still there under the soil, though they do not come up to the surface.

Mr. Hackett: Of course, you can always bring worms up to the surface by using any alkali or acid. Nearly all wormkillers depend on the property of irritating the worms. The worms are not really poisoned. The skin of the worm is simply irritated, and they die from shock, not from poisoning. You can destroy the worms in this way by using 3 oz. of perchloride of mercury to 50 gallons of water which gives a strength of .04 per cent., or three times weaker than that used for medicinal purposes. It certainly is the cheapest method and is equally as effective as any other. I do not think that any possible injury can come to the turf by its use.

Question: Would arsenate of lead have the same effect on worms, grubs, and weeds on all alkaline soil (as was stated in "Golfing") as on worms, grubs, and weeds on an acid soil?

Mr. Hackett: It would not have the same effect on weeds but it would have on worms and grubs. It is stated in "Golfing" that arsenate of lead is supplementary to the acid system in regard to weed control.

Question: How can you get rid of chickweed?

Mr. Hackett: I do not know how to get rid of chickweed. I have, however, given one green sulphate of ammonia every fortnight during the winter, which has brought the P.H. down—i.e., more acid—but not yet sufficiently acid—i.e., P.H. 4—to establish weed control. This green had much seasand for many years, and consequently the lime content is taking a lot of neutralising. The Americans suggest arsenate of lead will eliminate chickweed. In last month's Bulletin I have edited another article, showing how much should be used.

MOWING MACHINES.

Now, there is another point I would like to ask you about. What machines are you using on your greens? I am asking this because there is a new machine out to-day called the New Era Pennsylvania, which I consider the finest machine on the market? Have any of you used it? (Yes, at Bridge of Weir.) I think it is specially good for undulations. About a year ago the makers sent me their model. I got four or five greenkeepers to our course, and we had a field day testing this machine. We made about four suggestions for improvement of the machine, which we sent to the makers, and they embodied all these improvements in their latest model. I am not telling you that because I had anything to do with it, but the people are out to oblige and to take notice of anything we say. They are not like some manufacturers who say, "We know all about machines—you can teach us nothing."

Question: With regard to cutting grass, do you believe in cutting with the box on or off?

Mr. Hackett: I should certainly have the box on if I were cutting Poa annua when it was seeding. In regard to other times I think it is quite a good thing to leave the box off. You are adding humus to the green.

Question: Am I to understand that you are in favour of greens being cut by a motor mower?

Mr. Hackett: I am not. For one thing, I think the motor mower is not so quick. I certainly will back myself to cut a green with the Pennsylvania New Era quicker than with a motor mower. After all a motor mower can only go as quickly as a man can walk. Then you waste any amount of time in turning. If the ground is at all undulating, the machine bumps, and you are inclined to bark the top. Also, with the continuous vibration, the grass is not so closely cut.

Hamilton: I am sorry, Mr. Hackett, but I can't agree with you. I do not think at Hamilton that we could possibly cut the greens as quickly with a hand mower as with the motor mower.

Mr. Hackett: I am very glad to have this first note of opposition, and I can only say that I speaking from my own experience, but I would not make this claim for any hand machine other than a Pennsylvania New Era.

SULPHATE OF AMMONIA.

Question: We have absolute faith in our greenkeeper. What are the relative advantages of removing weeds by hand or by weed killer? You see the bulk of our members do not like the holes that are left on the greens when the weeds are removed by hand. The grass is heavy. Does it do the greens a great deal of harm to keep them in play during the winter?

Mr. Hackett: Dealing with the first, Nitram, Ltd., selling Agents for Imperial Chemical Industries, Ltd., have the monopoly of sulphate of ammonia. They have a very able lot of scientists at their head. You should treat every fortnight with sulphate of ammonia and water it in, and there should be no bare patches or burning of the grass. This certainly will not have any effect on plantains and they must be taken up by hand.

I do not think it hurts the greens to play in the winter. Shift the hole twice as often as in the summer.

Mr. Hackett: You mention the question of laying water to the greens. Very good. I am certain the ideal way of using sulphate of ammonia is to water it in. At Le Touquet, I have a friend who uses sulphate of ammonia in very small quantities, and he puts this on twice a week, and to my mind that is the ideal way. By having water laid on to the greens you also feel secure in cases of drought. At my home club we have not water laid on to the greens, but we have an engine and pump, and there are plenty of streams (burns) all over the course, which enable us to water every green.

Question: Do you advise treatment in winter as well as in the playing season?

Mr. Hackett: I don't advise composting in the winter, but there is no reason why you should not use sulphate of ammonia in the winter. It is, of course, rather wasteful, because the plants are dormant, but you are going to get your greens acid more quickly.

Question: Supposing you set out to change your greens to acid, and you don't have water laid to your greens, how much water would you use per square yard with sulphate of ammonia?

Mr. Hackett: Just sufficient to dissolve it.

British Creeping Bents.

By NORMAN HACKETT.

READERS may recall the notes in another article concerned with the American stoloniferous or creeping bents—the Washington and Metropolitan strains. Stolons chopped into pieces two inches long had been strewn on a bed (prepared as for seed). They were then given a light covering of soil—again in the manner of covering seed—and constantly watered for the first three weeks to accelerate germination at the nodes.

It is interesting to note that this experiment has been a pronounced success—these two beds to-day being composite, and dense turf that could be "lifted" if required. The turf is homogeneous in character—the stolons were strewn on soil that was naturally acid (3.8 P.H.)—and, no doubt, this fact has eliminated competition from the various weeds and Poa annua, etc.

While the experiment has been entirely successful from the point of demonstrating the practicability of the " stolon " method of making turf, we must say that we consider the resultant turf too "fluffy" for the best putting greens. Our American friends claim that if this turf (from both these strains) is composted every month, that such "fluffiness" is prevented, that the tendency for the stolons to appear on the surface is thereby stopped and the actual blades of grass are all vertical. One is willing to concede that this may be so; but I subscribe fully to a remark Sir Robert Greig, D.Sc., etc. (Head of the Scottish Agricultural Board), made to me in a letter some time ago—to the effect that we had stoloniferous grasses in Britain that he thought would prove superior in turf texture to either of the American strains. This is fully brought out in our experiments with Agrostis Canina—which grass has been mentioned many times in these columns—and it is very interesting to note that according to the results published in the latest United States Golf Association Bulletin this identical grass is now regarded over there as superior to the above-mentioned creeping bents.

Agrostis Canina is also a creeping bent. Readers will again remember that I have previously mentioned that it was a very shy seeder, and also that last July we planted out pieces of this grass from the sod, and, to our delight, it sent out noded stolons. These same stolons were cut off in September and planted for a stolon nursery. They have come along well, making very healthy plants, but to our surprise they developed flowering stems this June, and have seeded. We greatly wondered, having propagated their species in this way, whether or no they would have a second seasonal period of fertility, and send out stolons. This procedure has, in fact, obtained, and to-day the stolons are a foot long—noded every two inches—and no doubt, will extend to two feet before the of this month (July), when we shall cut them off and strew them for an actual turf bed for next season.

One naturally enquires as to why the same plant of this grass dibbled out last year did not seed, but only stoloniferated, and I think the explanation is quite simple—for last year *it was July* when we teazed out the sod and dibbled in the plants, and it would appear that they had missed the springtime urge of seeding, but had responded to Nature's call of perpetuating their species by stoloniferating. The plants dibbled out last autumn have thus this year been enabled to respond to both impulses. Messrs. Sutton & Sons in a letter to "Golfing" in June, 1928, made reference to Agrostis Canina, and emphasise the fact that it is a shy seeder. It certainly is not possible to buy this seed pure on the market at the present time, but one is seriously tempted to ask whether any systematic attempt has been made by our home seed-growers to select this grass and cultivate it for seed purposes. It is unquestionably the queen of grasses for putting green—having all the qualities of red fescue without its disadvantages. Red fescue by itself will never form a dense compact turf, and it has been pretty well proved that closer cutting tends to kill it out. Pluck a few blades of red fescue, and you will note that a point less than a quarter-of-an-inch above ground the stem forks into two blades. This bifurcation point is known as the axil, and where such blades are cut below this axil, as is inevitable with modern mowing machines, the plant is weakened.

In contradistinction to the fescue species are the bents or agrostes, of which canina is indubitably the best. The grass blades are so fine as separately to be almost indistinguishable from red fescue —but they grow upright—are in denser formation—almost resembling a pile carpet—and close cutting has the opposite effect to that on red fescue—the more one cuts, the denser grows the grass.

Agrostis Canina is a constituent up to as much as 40 per cent. of the seed which is commercially known as *South German Mixed Bent*—the remaining percentage is wholly Agrostis Vulgaris—its first cousin.

When I am asked " What grass is the best to sow for a putting green? " I have only one answer, " South German Mixed Bent." Red Fescue (Festuca Rubra) I omit for the reason given above— also every other fescue, unless it be a certified creeping red fescue. which in practice is a rarity.

Some seedsmen supply a putting green mixture " with or without rye grass." Why rye grass is even suggested I have never been able to understand; its blades do not grow upright, are very tough—and it is the one grass which when at all wet effectually resists the mower; set the cutting cylinder and sole plate of your best mower as you will—the result is simply laceration of the blades; every greenkeeper is familiar with this experience.

AN EXPERIMENT TO DETERMINE THE BEST HUMUS INGREDIENT.

The precise function of "humus" still baffles our agricultural scientists. What proportion of its presence and action is purely physical, and how much chemical has yet to be determined? It must suffice for the present that "humus" or decayed vegetable matter in some form is vital for the fertility of all plants and grasses whether the soil be acid or alkaline. Farmyard manure has for long been the "humus" ingredient of our composts for putting greens. The accepted proportions for a compost have been 80 per cent. loamy soil incorporated with 20 per cent. well-decayed farmyard manure, and for every ton or cubic yard of this mixture add 15 lbs. sulphate of ammonia. (Recently I have also added 15 lbs. of sulphate of iron with additional beneficial results.) A ton of this mixture is applied to 5,000 square feet of green surface—preferably every month during the growing season, and where this is not practicable every two months throughout the whole year. Such dressing is only the equivalent of one-sixteenth of an inch per square yard—which thin layer occasions no detriment to the putting.

We have been told by various authorities that if farmyard manure is left a whole year before being used for this purpose the weed seeds therein are rendered unviable. This may be true if such manure is housed under ideal conditions, when the heat so generated by fermentation should, undoubtedly, be sufficient to destroy the weed seeds, but observation and experience have led one to believe that in common practice the ideal conditions seldom obtain, and, therefore, the contingency of weed propagation from such manure is seldom eliminated.

It is with a view to getting some light shed on this problem that this spring we planned an experiment with three different kinds of material as humus according to the following table:—

A.

Soil and Horse Manure.

A.1.	A.2.
Sown with South German Mixed Bent.	Sown with Agrostis Canina.

B.

Soil and Leaf Mould.

B.1.	B.2.
Sown with South German Mixed Bent.	Sown with Agrostis Canina.

C.

Soil and "Humull."

C.1.	C.2.
Sown with South German Mixed Bent.	Sown with Agrostis Canina.

N.B. 1. The Agrostis Canina here sown was a few pounds weight sample, kindly sent to me from a Canadian Agricultural College.

N.B. 2. The soil was of a sandy nature, and contained no natural humus whatever. For this reason—and also to provide the fullest opportunity of demarking the results—the humus constituent in each case was 30 per cent., and thoroughly mixed with the soil.

N.B. 3.—The acidity of the soil itself was 3.8 p.h. Horse manure 5 p.h. Leaf mould 3.8 p.h. " Humull " 4.3 p.h. After incorporation the p.h. of the plots was as follows:—

A.—4.4 p.h. B.—3.8 p.h. C.—4.0 p.h.

All the six beds germinated and came along well. A.1 and A.2 made the best progress at the beginning—the grass grew quicker and seemed more healthy.

As I was looking at the beds six weeks after sowing, it suddenly dawned on me that this was perfectly natural, as A.1 and A.2 had the advantage of having quickly available nitrogen from the horse manure; whereas the availability from leaf mould and peat is much slower—and, indeed, it is very questionable whether peat has any available nitrogen at all, though this fact does not necessarily detract from its value as "humus," since it readily absorbs ammonium nitrogen) and passes it on to the plant.

At this point, therefore, I supplied nitrogen to all six plots (purposely not omitting A.1 and A.2)—represented by half-an-ounce per square yard sulphate of ammonia. This was followed by periodical cutting and after three weeks' interval another S/A application. It was surprising to note how the two B. and two C. plots responded to this treatment. The extra nitrogen to the A. plots seemed to make very little difference (there was a very ample supply from the horse manure). To-day, the B. (leaf-mould) plots are the best, closely followed by the C. ("humull")—both have healthy stands of grass. While there is a good growth on the A. plots, the grass does not look so healthy, and has a more forced and rank growth. The probability is that in the case of the horse manure 30 per cent. was too much. Further experiments suggest themselves with varying percentages of the three humus materials in each case.

The experiment, however, seems to be instructive and serving its purpose, for a few weeds and two small clover plants have already appeared on the A. plots, but not a vestige of the same on either the B. or C. plots and while the result cannot yet be termed conclusive, the indications are there, and we trust useful knowledge will ensue.

Bare Patches,

By NORMAN HACKETT.

IT is Sunday afternoon, August 5th, and I seek inspiration on the sand dunes of the Seascale Golf Club, Cumberland. The sixteenth green is just in front of me, and immediately beyond, the sea—as calm as a mill pond—but with just enough ripple to glitter in the sunshine of this glorious day.

It is not without a tinge of selfish satisfaction that one noted in the morning's papers that there was "no play at the Oval" yesterday, owing to rain, while we here have enjoyed uninterrupted sunshine since our advent on Wednesday. For we really get a little jealous sometimes in the North when we hear of the tropical weather in the South while we are shivering in a snowstorm and one is thankful to Nature for readjusting the balance, if only for the once.

The holiday spirit, and the wonderful setting of my position —the lake—hills behind—St. Bees Head, and the Scottish hills to the North, while the Isle of Man is faintly visible on the horizon—are hardly conducive to thought of worms or acidity; but in a rash moment I promised the editor that, despite holidays my contribution would be available, so I must keep faith.

This page is hardly the medium for a personal causerie, but I shall not be satisfied unless I relate a pleasing experience that graced this morning's round.

I played a clergyman visiting here on Friday—one of the best. I told him the answer of the schoolboy, who, on being asked, "What was the difference between a problem and a theorem?" replied that "A problem was a thing anybody could do, but a theorem required divine assistance." He rejoined with a boy's "howler" about Elijah, who characterised the prophet as "A bald-headed man who went for a cruise with a widow." This morning (Sunday) I was one of a four-ball with the professional, when my clerical friend appeared on the first tee, intimated that he wanted to get a few playing tips, and could he caddy for me? I told him I knew he was a parson, but that he must be a boy scout as well. Needless to say, I accepted his kind offer with alacrity, and to the envy of the other three, who had to bear the "heat and burden of the day" for themselves. It was only at the eighteenth tee that with difficulty I persuaded him to relinquish his task, and not expose himself to the voice of the multitude which takes its after-Church stroll alongside this fairway.

And now to the subject of the Green Committee page proper.

In April of this year, in response to a request, I visited a northern links of a seaside character, subsequently sending them a report which I give verbatim below:—

"Following my visit on Sunday, April 15th, I have pleasure in handing you this somewhat lengthy collection of my impressions, opinions, and recommendations.

" While I do not want to be thought dogmatic, it represents my considered views within the extent of any small fund of knowledge I may have acquired.

" First, I would deal with the matter that has occasioned you most anxiety, and which was the primary reason for your invitation to me. I refer to the bare patches and hollows on a few greens as exemplified by Green No. 13.

" I understand that these greens have had no unusual liming, fertilising, or worm-killing treatment—the reply to my query in this respect being that complete fertiliser alone has been used, and about a bucketful of lime per green. One assumes that these were spread or dusted on evenly, and, such being the case, they can be eliminated from our consideration.

" You state that these patches developed after a spell of snow—slight thaw and sudden frost—the theory being that before the water of the thawed snow had percolated into the soil, it froze solid—presumably remaining frozen for a few days. Here again, one assumes that no attempt was made mechanically by any irresponsible workman, or even player (with a club) to remove such frozen snow. Then, after the final thaw, these patches were noticed. I think I am right in saying these are the known facts, and as presented to me. If one now appears to argue with oneself, it is because it is difficult to believe, even if this exact sequence of weather conditions took place that *on your porous, sandy soil* they should account for the trouble. It is, of course, a fairly common experience to get " winter kill " of turf on a clayey, impervious soil—especially when icebound for a considerable period. Since my visit I have examined particularly two of our greens at Keighley, and one at Hawksworth, certain hollows on which I know were frozen for a period this winter. In all these three cases there is clay almost under the sod, *but no damage to the turf ensued*.

"Snow *mold*, a very uncommon occurrence in this country, can, I think, be definitely ruled out—it could not in any case be responsible for what one might term the apparent almost "uprooting" of the turf, leaving, as it has, bare hollows.

" My phrase, ' even if this exact sequence of weather conditions took place,' is occasioned by mental query, because it is not easy to imagine this sequence as happening on your sandy soil; one would, I think, be justified in postulating that any snow actually thawed to water would immediately percolate into the norous soil, and could not remain on the surface to be frozen. As against this it might be advanced that if there had been a *hard frost before snow fell*, on a very temporary thaw setting in, the snow water would not percolate the hard frozen turf. Incidentally, it is curious that only some greens are affected, and only portions of these. These affected places, moreover, are not in any hollows, which does away with any theory that it might be seepage snow water from a higher point.

"We are now thrown back on to the problem, granted these exceptional physical conditions—why should your greens have suffered, and not those of a course, for example, like my own ·t Keighley—where our turf has been subject to conditions even more severe, *e.g.*, little frozen pools on a green for days?

"After thinking this question over very carefully, there is only one cause I can advance, which, moreover, is correlated to what, in my opinion, constitutes a serious deficiency in the constitution of the top soil of your greens. I refer specifically to a lack of humus. By 'humus' is meant a decayed (mainly) vegetable product such as old farmyard straw manure, peat manure, leaf-mould, or even some forms of peat itself. The precise functions and reactions of humus, both from the physical and chemical aspects, are still the subject of scientific research; suffice to say that the fact is established that its presence is necessary for the process of complete fertilisation, with its consequent nourishment of, and vitalising influence upon plant life. Your greens are unquestionably deficient in humus. It is more than plausible that their constitution has been thereby so weakened that they are not able to offer resistance to these abnormal weather conditions.

"I was given to understand that for years the main treatment accorded to your greens has been the application of your *sub-soil sand*, no earth, loam, or manure (apart from artificial manures and lime) having been applied. In my opinion this procedure has been wrong for two reasons:—

"(1) The original top soil itself is of a very sandy nature. *It does not require the incorporation of more sand;* but it does require the ingredient 'humus.' For your soil I cannot advise anything better than *leaf mould*, which I understand is available from a wood near at hand.

"The Le Touquet (France) Golf Course has almost identical soil conditions as yours—their greens are admittedly among the best in Europe. Dr. Oakley, the chairman of the United States of America Scientific Green Committee, after a tour two years ago, in which he visited the best representative Continental and British courses—told me he considered them *the* best. I have visited Le Touquet several times, and agree with Dr. Oakley. On one occasion I spent the whole day on the course with Mr. Dennett Barry, the secretary-manager, who had entire charge of the greenkeeping; and leaf-mould and sulphate of ammonia have been his two main planks for years.

"(2) Your sub-soil sand is highly calcareous, i.e., it has a very high lime content. On the contrary your four inches of top soil is very acid, recording under 4.5 p.h. I am not referring now to the greens, but to 'pretties,' and these facts were determined by actual chemical tests. Lime in any form will cause a gradual transition in the grass flora, the fescues and agrostes will be eventually superseded, and almost entirely replaced by the lime loving pasture grasses, i.e., Poa annua, rye grasses, Poa trivialis, Poa pratensis, etc., and it is these latter grasses to-day that constitute 90 per cent. of your greens; whereas, in contradistinction to this, your acid top soil fairways retain *their original springy mat* (due entirely to acid conditions) and the fescues and fine agrostes which are acidophil grasses.

" N.B.—Neither worms nor weeds like an acid soil. Your acid fairways are practically free from weeds, *and I venture to submit are also free from worm casts, even under wet autumn and spring conditions.* On the contrary you are always having to rod and wormkill on your greens, owing to their alkaline condition.

" N.B.—The last fairway we examined had lost its mat character and weeds were in evidence. You may remember I hazarded the belief that I did not think this could be acid, and on testing the same this surmise proved to be correct. On enquiry it appears that this fairway (and I understand others also) have been limed. In the light of modern research, this practice of liming acid fairways for golfing purposes is utterly to be condemned. If it is desired to turn such fairways into meadow pasture land, then, of course, it is the proper course to pursue.

" Correct me if I am in error, but previous to my visit I had heard more than once that it has been a traditional practice at—— to put your sub-soil sand on to the greens, and their excellent condition has been attributed to this treatment. I am of the opinion that this condition has been obtained *in spite of this practice;* that this excellence was due primarily to the ideal natural and acid state of the top-soil—the turf of which responded to *cutting and fertilising*—and the *credit was given to the sand.* Continuous application of the lime-containing sub-soil sand, lime itself, and complete fertilisers (which are alkaline reacting) have at long last *nullified the original acid state and the grass flora indigent thereto,* and reduced (or in purely agricultural terms—enriched and fertilised) the soil to a more favourable state for the growth of the meadow grasses as opposed to the acid-loving fescues and agrostes.

" N.B.—A comparison of the flora of the greens (all alkaline) with the acid fairways demonstrates this fact.

" N.B.—Your 13th green, which was newly-made or re-turfed only a few years ago, still preserve more of its original grass flora than any other.

" To sum up I would recommend:—

" *Fairway treatment.* Avoid application of lime in any form. If any treatment is required, apply next March or early April 150 lbs. *sulphate of ammonia*, mixed with 450 *parts of your top-soil to every acre of fairway.*

" *Green treatment.* Avoid application of lime in any form—either as lime or your calcareous sub-soil sand. Discontinue further use of any alkaline fertiliser. Compost the greens from now onwards until end of September, every four weeks, with a compost made of equal parts your top-soil and leaf-mould, to every ton of which mixture is added 15lbs. of sulphate of ammonia and 10lbs. sulphate of iron. For every application use one ton (equals one cubic yard) to every 5,000 square feet of green. Broadcast this on the green with a shovel, then use the back of a wooden rake for a complete, even distribution. As you have water laid on every green, get the sprinklers working for several hours the evening of such application. N.B.—This composting will not interfere with the play of the green—it only represents a covering of one-sixteenth of an inch.

" From October to February, compost with leaf-mould and sulphate of ammonia only, cutting out the sub-soil, i.e., one ton leaf-mould plus 15lbs. sulphate of ammonia to every 5,000 square feet.

" N.B.—Leaf-mould is recommended as the humus content (which your greens lack), as opposed to well-rotted manure, for the following reasons:—

" (1) It is free from weed seeds.

" (2) It is acid—all tests I have made show 3.8 p.h.. Horse manure is slightly alkaline—7.2 p.h.

" (3) It is easily procurable in the near vicinity.

" (4 a) Its use is amply justified by the Le Touquet results.

" (4 b) A more homely but very pertinent appreciation of its value is afforded by the gardener, whom experience and practice has taught that soil, silver sand, and leaf-mould is the ideal ' potting ' mixture.

" (4 c) Its value as ' humus,' and also as a nitrogenous fertiliser, has long been recognised.

" (4 d) It also contains sufficient phosphoric acid and potash to meet the requirements of the finer grasses.

" The leaf-mould shall at all times be sieved through one-eighth-of-an-inch mesh.

" In practice, a large framed quarter-of-an-inch mesh is used first to take out all small twigs, etc., and subsequently the leaf-mould is passed through the one-eighth-of-an-inch sieve.

" N.B.—The *neutral* sulphate of ammonia should be bought; not, one might say, because it is called neutral—by reason of the fact that is contains no free acid—but because it is composed of finer crystals, and, being hydrated, does not become lumpy."

I had motored the 70 miles odd to this links on a Sunday, only advising them the day before by telephone of my visit. On account of this short notice on my part the chairman was the only member of the green committee who was able to accompany me on the links in the examination, and, at the conclusion, he was most anxious that I should put my opinions in the form of a report for the benefit of the other members. This I was pleased to do, knowing full well that what I had to recommend as far as concerned their practice was revolutionary. When I wrote out and sent them this report a few days later I felt almost convinced that it would not be adopted on this account, and as I was most anxious that they might have advice that they would have confidence in carrying out I telephoned my friend, Professor R. S. Seton, the Head of the Agriculture Department of Leeds University, told him the whole circumstances, and besought him to go over with me. He very kindly acquiesced, and also brought a colleague with him, Professor Robertson. On this occasion all the members of the Green Committee were available, and we spent four hours on the links, and again made at least a score of soil tests for p.h. values. At the conclusion my professional friends intimated that they thoroughly endorsed my report. I readily admit I was gratified at their concurrence, but the point I want to make is that these two purely agricultural scientists recognise the validity of the acid theory for golf turf purposes as opposed to liming and consequent alkaline conditions for agricultural and crop purposes.

Retrospection and Reiteration.

IT is just two years ago since the theory and practice of the acid reacting fertiliser was expounded in "Golfing." Many clubs have adopted the system during the last two years, and it is very pleasing to record the receipt of an increasing number of letters, all testifying to the satisfactory results obtained.

If only an initial measure of success had been achieved, it would be especially gratifying, because in no case yet has the system been long enough in operation to make any substantial reduction in p.h. values, i.e., down to that degree af acidity (4 p.h., and below), at which point the geratest measure of weed control is established worms are not in evidence, and Poa annua and other lime-loving grasses are being displaced by the true turf-forming acido-phil agrostes.

This acidifying action by an acid fertiliser, i.e., sulphate of ammonia, is a long process. Even starting with a soil that is neutral (6.0 p.h.), it will take eight monthly applications of sulphate of ammonia at the rate of half-an-ounce per square yard every year for four years until 4 p.h. is reached.

It must be distinctly understood that at least every alternate application of sulphate of ammonia should be given along with the compost, and, *unless it can be watered in*, sulphate of ammonia should never be put on "neat," but mixed with three times its weight of sandy loam, in order to ensure even distribution, and to avoid "burning" of the turf. Precautions must be taken to see that any sand used in the loam is free from lime in any form, and for this reason *sea-sand is tabooed.* The simple and well-known test is to pour a few drops of hydrochloric acid on such sand or soil—where lime is present, a bubbling effervescence arises—represented by the following equation:—

$$\text{Ca Co}_3 + 2\,\text{H C L}$$

Carbonate of Lime — Hydrochloric Acid

$$= \text{Ca Cl}_2 + \text{Co}_2 + \text{H}_2\text{O}$$

Calcium Chloride — Carbonic Acid Gas — Water

But every greenkeeper should possess himself of a *soil testing outfit*, so that in making his compost he may prospect around on his links to find the most acid soil. Not only should the top soil be tested, but also at a further depth of every two or three inches, because it is often found that while a surface layer is acid, below that it may show varying degrees, even to alkalinity. Therefore, since the whole idea of using sulphate of ammonia is that, after it has given up its nitrogen to the plant it leaves and imparts to the soil an acid residue, it will be appreciated that a naturally acid soil for the compost-making is half the battle.

Every greenkeeper and gardener knows the value of leaf-mould—if he can get it—and let me say that all leaf-mould I have tested is very acid—in every case under 4 p.h.—so when we talk about an acid fertiliser or an acid soil, let no one be apprehensive. Moreover, I would advocate leaf-mould instead of stable manure (however well-rotted and broken down) as the "humus" constituent for the compost. It has the advantage over stable manure of being acid, weed-seed and worm free, and, apart from its physical qualities, contains rather more direct fertilising products. A ton of leaf-mould contains approximately:—Nitrogen 22lbs., potash 7lbs., and phosphoric acid 7lbs. Experiments I have made in seed beds this year with a proprietary humus—"Humull"—also seem very satisfactory. Both leaf-mould and "humull" are giving better results in the beds than farmyard manure.

One hopes that these facts may be of service to greenkeepers, who, this winter, will be making their compost and applying it in accordance with modern practice during the growing season.

Let me interpolate here that experiments have proved that *there is enough available phosphorus and potassium in the soil of the compost for the needs of the grass.* This point was stressed in the very first article I wrote on this subject, and has been constantly repeated. Perhaps it is owing to the almost unavoidable reiteration of the use of sulphate of ammonia that accounts for it, but I still get an occasional letter asking me if I am aware that no plant life can exist without potash and phosphorus, in addition to nitrogen.

The writer is more than ever convinced that the acid-reacting fertiliser treatment, along with the compost—and absence of lime in any form—is correct, and produces the best results. During the last two years it has religiously been carried out on the greens of the two clubs of which I am a member—Keighley and Bradford (Hawksworth)—and which greens, naturally, come under my constant closer observation. There has been a continuous improvement in the quality, density, and stand of the turf, together with the attainment of a perfectly true putting surface.

Old traditions and customs die hard. We still meet the Green Committee member whose farming agricultural knowledge and experience make him not only sceptical, but actually scornfully hostile to this new treatment. He would still treat our fairways with lime or basic slag (a compound of phosphorus and lime)—as he (rightly, of course) treats his pastures—but we do not want the coarse, hay pasture grasses or clover on fairways; he would give our greens sulphate of potash and superphosphate of lime knowing how these benefit his root crops (e.g., potatoes cannot be grown successfully without the considerable use of potash and superphosphate)—not recognising that the slightest *excess of potash* especially encourages the tap and bulbous-rooted weeds, e.g., dandelions, buttercups etc. He knows that sulphate of ammonia and nitrate of soda are the two chief fertilisers that supply nitrogen, but he does not know that *sulphate of ammonia is an acid-reacting* fertiliser, and that *nitrate of soda is an alkaline-reacting* fertiliser; nor in farming does he need to appreciate the distinction. And to complete the indictment, he is not aware that, among his own agricultural scientific authorities, those who have studied the matter, subscribe to this acid theory. Let me give the pronouncement of one of them—that of Sir Robert Greig, K.B.E., F.R.S., D.Sc., Head of the Board of Agriculture for Scotland, who writes me as below, with permission to publish:—

" The agricultural knowledge available in this country has been directed to the stimulation of crop growth and to the production by breeding or otherwise of strong growing grasses and other herbage. The object of the good greenkeeper is to have the finest possible and most uniform surfaces of grass on his putting greens, and to secure a fairway which will always hold up a ball, so that it may be cleanly hit (apart from hazards, and so on), in any condition of the level, and on any type of soil. *There is nothing in all agriculture which has any direct bearing upon such subjects.* It is, therefore, useless to call in a gardener or farming expert to deal with golf courses in being.

" As an example of the divergent aims, sulphate of ammonia is used in agriculture to stimulate plant growth, and if used often enough and in sufficient quantity will so deplete the soil of lime that certain plants, as for instance, barley, will scarcely grow at all. The skilled agriculturist would, therefore, apply sulphate of ammonia where he knew there was a sufficiency of lime, and obtain heavy crop growth, but the object of the greenkeeper is to reduce the growth of grass, and, if he can do this by making certain soils acid and *lime hungry*, he uses sulphate of ammonia for that purpose. The demonstration of the effect of an acid fertilser, such as sulphate of ammonia, is explained by the results of soil tests once it is realised that *the finest putting grasses grow best on a sour or non-alkaline soil.*"

The B.D.H. soil testing outfit, supplied by the British Drug Houses, Ltd., of Graham Street, City Road, London, N.1, is designed for actual use on the field or links, and consists essentially of a dropping bottle, containing the B.D.H. Soil Indicator, and a specially designed porcelain boat, which is divided by a partition into two unequal parts. One end of the boat is used for mixing the samples of soil with the indicator, and the smaller end for the reception of the coloured liquid which is drained off from the mixture.

A red colour indicates a very acid soil. An orange or yellow colour indicates an acid soil. A green colour indicates a neutral soil. A blue colour indicates an alkaline soil.

The precise changes of colour indicating p.h. degrees are as follows:—Full red, p.h. 4.0. Orange red, p.h. 5.0. Orange, p.h. 5.5. Yellow, p.h. 6.0. Greenish-yellow, p.h. 6.5. Green, p.h. 7.0 (neutral). Blue, p.h. 7.5.

The Nature of Soil Acidity.

From an article by O. J. Noer, in the official Bulletin of the U.S.G.A., Green Section.

A CLEAR understanding of what constitutes soil acidity, how it develops, the effect of specific fertiliser materials, and the possibility of introducing lime or other alkaline material in sand, soil, or water, must be considered in any programme aimed to promote soil acidity.

Natural agencies tend to make soils either more or less acid. In humid regions (25 inches or more annual rainfall) soils gradually become acid, and less acid or alkaline in arid and semi-arid regions. During and after rains, the excess water as it passes down through the soil dissolves and removes more alkaline than acidic material, consequently the residual soil gradually becomes acid in character. In semi-arid and arid regions, almost no water passes down through the soil. Evaporation at the surface tends to promote capillary water movement upwards, and the dissolved materials, usually alkaline in character, accumulate as the water evaporates. Since these materials are water soluble, they can be washed out of the soil. Removal is facilitated where tile drains are installed to carry the leaching waters away.

The rate at which acidity develops naturally depends upon the amount of rainfall, the type of soil, and the nature of the native material from which the soil was derived. The more thorough leaching in areas of heavy rainfall is self-evident, but that acidity develops more rapidly in sandy than heavy soils is not generally appreciated. If the parent rock from which the soil originated was low in alkaline materials, acidity asserts itself more quickly. Soils derived from limestone usually contain lime carbonate, and, until removed, acidity develops slowly. Carbonic acid, always present in the soil water, gradually converts the insoluble lime carbonate into soluble bicarbonate, which leaches from the soil. From 200 to 500 pounds of lime are annually removed in this way. Sulphate of ammonia hastens removal by converting additonal lime carbonate into soluble calcium sulphate, which is also washed out in the drainage water. But until the lime carbonate disappears completely very little effect can be expected from the sulphate applications so far as increasing soil acidity is concerned.

Chemists recognise three classes of substances, acids, bases, and salts. As the name implies, acids are acidic in character, whereas bases are alkaline in character. Salts are usually neutral, but may have acidic or alkaline properties. They are formed when chemical action takes place between an acid and a base, and may be either soluble or insoluble in water. When an acid and base react together they neutralise each other, each losing its distinctive properties. Yet salts are not always neutral. They may have acidic or alkaline properties. Just as the forceful individual dominates the weaker, so the strong acid or base imposes its will on a more feeble companion, and the properties of the stronger predominate. Water may dissolve and remove acid or basic materials from insoluble neutral salts leaving a residue either acid or alakaline in reaction.

Soils consist essentially of exceedingly complex organic and mineral salts, almost wholly insoluble in water. It is from these substances that the more soluble basic materials are dissolved, and eventually removed from the soil by the percolating waters. The insoluble soil residue thus becomes acid in character and, is the reservoir from which soluble acidity develops, when soluble salts are added to the soil. The mechanism of the process can be demonstrated easily. If a fragment of granite rock is ground to a fine powder, placed in a bottle, water added and vigorously shaken the water gradually becomes alkaline, due to the solution of basic substances. When the water is removed the acid nature of the insoluble residue, caused by the solution of bases, can be demonstrated. If water containing a neutral dissolved salt (such as sulphate of ammonia) is now allowed to come in contact with the acid rock powder, it becomes acid in character. The powder takes up and holds the basic portion of the salt (ammonia), and leaves a soluble acid (sulphuric acid) in the water. In humid regions the percolating waters dissolve and remove alkaline materials, leaving an insoluble soil residue capable of developing soluble acids when certain fertiliser materials are added to the soil.

The predominating opaque grains in sands are quartz or silica, a substance so insoluble and inert chemically that it has very little effect on soil reaction. Variations only result from changes in the fine mineral particles or inorganic matter, and since these constitute only a small portion of sandy soils, changes occur more rapidly than in the heavier soils.

There is a rough correlation between the insoluble and soluble soil acids. Soils containing large amounts of insoluble acids are capable of yielding much soluble acidity. It is soluble or active acidity which controls growth of grasses, clover, and weeds.

Soils have remarkable power of resisting change in reaction. This power resides mainly in the organic matter, silt, and clay particles, so permanent change takes place more rapidly and completely in sands than in the heavy soils.

Continued Research Sustains Acid Fertilisation.

BY NORMAN HACKETT.

A CRITIC of what he is pleased to describe as my " campaign for the use of sulphate of ammonia " lays emphasis on the contrast between " the views of the most skilled professional seedsmen, who have the knowledge of accumulated generations of scientific research," and those of one who has only taken the question up as an " engrossing hobby." The "engrossing hobby" is, of course, a reference to my author's note to " Soil Acidity, The Vital Importance of Topdressing, and Other Notes."

I do not object to the veiled sarcasm and implied inference. The use of these words in this connection is quite legitimate, and the argument deduced plausible. For how can it be expected or tolerated that an amateur delving into these problems should gainsay " the knowledge of accumulated generations " ? And, pray, what are " accumulated generations " ? The phrase almost suggests humus. Should not this read " accumulated knowledge of generations " ? But, here again, in journalism I am only an amateur.

Now if the principles and practices of the acid fertilisation treatment, in conjunction with composting, had been my own work and discovery, one would agree that they should be most suspiciously entertained, but the plain outstanding fact is that they represent the considered opinions of American scientists, who have now devoted eight years of continued and assiduous research solely to the problem of turf production and maintenance. Let me make the confession that, five years ago, I was a zealous apostle of liming—in fact my first contribution to "Golfing" was in the form of a letter advocating its use and decrying what I then thought in my ignorance was wrong, this new theory of acid soil. It was not until I had mentally forced myself not to regard old-established practices and customs as necessarily correct that I began to examine the case for acidity. In my opinion, the value of this treatment has been proved up to the hilt, not only by the U.S. Scientific Green Committee's researches, but ample confirmation is afforded by the fine turf invariably found in this country, growing on *naturally acid* soils, and also from the practical results obtained up to date by experiment and treatment here.

In connection with this discussion — lime — acidity — sulphate of ammonia—that is now engaging so much attention in "green" circles, it is necessary for me once more to state that no one has ever advocated the use of sulphate of ammonia by itself as the complete fertilising medium. It should be used along with the compost, and it is the compost and its humus content that supply the *necessary potash and phosphorus*, the presence of which is, of course, vital. Odd applications of sulphate of ammonia neat, watered in, or applied dry, mixed with three times its bulk of compost, should be given when for any reason it is not possible to apply it with the full amount of compost every month (during the growing season).

One must also refer to the phrase, "The campaign for the use of sulphate of ammonia." It is almost common knowledge that the production and sale of sulphate of ammonia is a monopoly of Imperial Chemical Industries, Ltd., and, equally, *both a fertiliser blender and a golf club* must obtain it from this source. On many occasions recently it has been suggested and conveyed to me that this advocacy of sulphate of ammonia was all a selling stunt on the part of this firm. Perhaps the best reply would be to state two facts: (1) That I.C.I. make *every kind of fertiliser*, i.e., nitrogen. potash, and phosphorus compounds; that they also own many lime quarries, selling huge quantities of lime; and it was recently announced that they had bought the Dead Sea concession for their potash requirements. It does not matter one iota which particular fertiliser they offer to golf clubs—*be it lime or sulphate of ammonia.*

(2) Apart from the large supplies of sulphate of ammonia that are made by all gasworks, collieries, and other distillation plants, the big synthetic sulphate of ammonia factory at Billingham produced last year 1,000 tons per day. Output this year is to be 2,000 *tons per day*. There are exactly 1,500 golf clubs affiliated to the four National Unions. *One day's output* represents as much as all these clubs could possibly *use on their greens in a year*!

May I here inform my readers that these facts were gleaned from the press, and also that I am neither in collusion nor correspondence with this firm on this question. The only department I am at all in touch with is their research repartment, who have an absolutely unfettered and unqualified mandate to *pursue research per se* in any direction and for any purpose. Whatever criticism may be levelled at these huge industrial combines of unlimited resources, this item is certainly on the credit side.

The U.S. Scientific Green Committee and Research Station came into being in January, 1920. Some two years later their investigations and researches led them to doubt our traditional agricultural methods of turf culture, which up to then they had subscribed to and followed. The outstanding result of their eight years' labour has been the establishment of the acid fertiliser treatment, along with composting during the growing season. It still represents to-day their considered and proved tenet, and I give below a verbatim extract from their October, 1928, Bulletin:—

Acid soil and sulphate of ammonia best for putting greens.—We have had the soil on our bent putting greens tested, and find it is slightly acid. Should we try to sweeten it? We have also tried a special commercial fertiliser on one patch of grass, while we have used compost alone on another; the fertiliser gave very much better results. Should we discontinue using compost?

Answer: A slightly acid condition of the soil is desirable, as fine turf grasses thrive in such a soil, while some weeds are discouraged. You have evidently a slightly wrong impression regarding the use of compost. Usually compost contains slightly less than 1 pound of nitrogen, half-a-pound of phosphoric acid, and 1 pound of potash, per 100 pounds. Putting green turf only occasionally requires more phosphoric acid or potash than the compost supplies. Also, if phosphates and potashes are supplied in excess of the turf requirements, clover, chickweed, and various other weeds may be encouraged. Putting green grasses, however, require nitrogen in addition to that contained in compost. The best form of nitrogen, other things being equal, is sulphate of ammonia, which also aids in acidifying the soil. Sulphate of ammonia should be used several times during the year, in addition to compost. Apply it at the rate of 3 pounds in hot weather, and 5 pounds in cooler weather, per 1,000 square feet. Mix the sulphate in a sufficient quantity of dry soil to insure an even distribution, and follow the application by thoroughly watering the sulphate into the turf. The brand of fertiliser you are using is a comparatively expensive source of nitrogen. It contains 7½ per cent. available nitrogen, while sulphate of ammonia contains 20 per cent. or nearly three times as much; at the same time the sulphate can usually be obtained at less cost per ton. You would be well advised to try sulphate instead of the fertiliser you now use, making applications whenever the grass seems to lag or need stimulation.

No Worms in an Acid Soil !

BY NORMAN HACKETT.

We have frequently referred to the fact that worms are not found in an acid soil, and the writer has often pondered over and sought for the explanation. Recently my friend, Mr. Percy Clough, the President of the English Golf Union, furnished me with the probable reason. He had been reading Charles Darwin's book: "The formation of vegetable mould through the action of worms, with observations on their habits," and found there was a whole chapter on the *calciferous glands* of the worm. Let me give two extracts from this chapter: "The pharyax leads into the œsophagus, on each of which, in the lower part, there are three pairs of large glands, which secrete a surprising amount of *carbonate of lime.* These calciferous glands are highly remarkable, for nothing like them is known in any other animal." "It is known that various kinds of acids are generated by the decay of vegetable matter; and from the contents of the intestines of worms being acid it seems probable that the process of digestion induces an analogous chemical change in the swallowed, triturated and half-decayed leaves. The large quantity of lime secreted by the calciferous glands apparently serves to neutralise the acids thus generated; *for the digestive fluid of worms will not act unless it be alkaline.*"

Just as human beings cannot live without common salt, it would appear that worms cannot exist without lime in their systems; and since they can only obtain lime from the soil, it follows that an acid or non-calcareous soil cannot support them.

Darwin records that worms are quite absent in peat and "places where heath and gorse grow," but curiously enough he does not seek to account for this fact. The explanation must surely be acidity.

As far as one can gather from his book, Darwin made all his observations and studies of worms in the vicinity of his home in Kent, which he himself says was situated amongst a chalk formation.

Darwin's book was published in 1888—forty years ago—and yet the apparent deductions seem to have escaped notice.

This mild late autumn has been especially favourable for the activities of worms; complaint on this score has been general. The main hope for permanent immunity lies in the creation of an acid soil. The continued use of sulphate of ammonia to accomplish this state is expensive for fairways, and takes a long time. Scientific research should and will, in my opinion, solve the problem, for experiments in hand already hold out much promise.

At the height of the worm season I spent a week-end at

St. Andrews. The trouble was so acute that they had used four tons of mowrah meal on part of the area comprising the 1st, 2nd, 16th, 17th, and 18th fairways, and another four tons would not have cleaned up this particular area.

I made many soil tests for p.h. values on the old course. All these *fairways* above mentioned were alkaline, and in contra-distinction the 14th fairway—the celebrated "Elysian fields"—was very considerably acid, showing an average p.h. value of 5. *The "Elysian fields" are always free from worm-casts.* Moreover, in other respects it is the best fairway on the course; the finer grasses predominate; there are exceedingly few weeds of any kind; and the turf has a resilient mat; all these conditions are identified with an acid soil. Wherever one goes, this striking phenomenon always presents itself, and has convinced me to record the following lines in my recently published booklet:—

"*That the p.h. value of soil is the chief governing factor determining the genus of grasses growing therein*—irrespective of the physical constitution of such a soil (i.e., whether it be of a sandy, gravelly, loamy, or clayey nature). This postulation is based on the accumulative evidence of soil tests made by the writer and applies equally to seaside and inland links. The grass red fescues is an exception to a certain degree, but only under certain specific conditions. It follows, therefore, that the acid reacting fertilising treatment should be *followed on every type of soil*—the only *varying factor* being the soil constitution of the top-dressing, and the amount and nature of the organic matter (humus) incorporated therewith."

ARSENATE OF LEAD TREATMENT.

When at Buxton a few weeks ago I was greatly interested in the experiment carried out at the Cavendish Golf Club with this chemical by Colonel A. J. Thompson.

In response to my request he was good enough to send me a report on this treatment:—

"Experiments during 1928 with arsenate of lead as a weed control and worm killer on the Cavendish Golf Course, Buxton:

"(1) Two plots of (A) 290 and (B) 390 square yards respectively had been got ready during the winter and spring for sowing with grass seed.

"On 7th May plot (A) and on 8th May (B) were poisoned with arsenate of lead, at rate of 35 lbs. per 1,000 square feet, in the manner described in the Bulletin of the United States Golf Association Green Section of February, 1927, and mentioned in "Golfing" on February, 1928.

"On 1st June plot (A) and on 4th June plot (B) were sown with grass seed. The poisoning did not affect the germination of the grass seeds, but proved very effective as a weed control. The weeds in these two plots have been only about five per cent. of the weeds on two non-poisoned adjacent plots. Also the plots have been almost free of worm casts, although these are very numerous on the surrounding ground.

"The dosage of 35 lbs. to 1,000 square feet was that given in the Bulletin of February, 1927, but in the February, 1928, Bulletin it is stated that further experiments have shown the 5 lbs. of arsenate of lead to 1,000 square feet is sufficient provided it is worked into the soil to a depth of half-an-inch only instead of two or three inches as previously advocated.

"(2) Use of arsenate of lead on established greens—described in the Bulletins mentioned above.

"All greens were dressed six times during the growing season with sulphate of ammonia and compost. In the last four dressings on ten of the greens, on which worms are very troublesome, arsenate of lead (amount varying from 5 to 10 lbs.) was mixed with compost.

"The effect of this treatment as regards weed control cannot be definitely judged. As regards worms, these have certainly been less troublesome than in previous autumns.

"It is proposed next summer to add 5 lbs. of arsenate of lead in each of five dressings of compost on these greens. There should then be sufficient evidence on which to judge the effect of this treatment on worms.

"This treatment has certainly no ill effects on the grass. On the contrary, as stated in the Bulletin of February, 1927, the grass on the poisoned greens appeared to be more vigorous, denser and of a better colour than on the unpoisoned."

Tragedies, Comedies and Romances of Greenkeeping.

BY NORMAN HACKETT.

GREENKEEPING has been called an art; it is more and more becoming duly accredited as a science; without doubt it is a combination of the two faculties. When, at some future date, a reviewer comes to write the history of greenkeeping, it will be found that its tragedies and comedies will be generally identified with its period as an art, and that its romances only revealed themselves under the more penetrating light of science.

Who of us is not familiar with the vicissitudes that in our time have accompanied its first era of life?

"A Tragedy of Errors"; "Much Ado for Nothing"; and "Lime's Labour Lost," might very suitably be inscribed on the walls of many a green committee room.

Do not we all recognise now to our chagrin and sorrow that when our course was first constructed the exercise of a little more forethought would have obviated the subsequent and in many cases, successive alterations?

When we have wondered why a new green would not drain, or have found its grass or turf would not " come on," have we not kicked ourselves when we have discovered that the contractor has not replaced the top soil, but left clay almost directly beneath the sod? Of course, this was nobody's fault, it never is. The architect left it with the constructor, the latter to his foreman, and so the responsibility was shifted to people who, while they possessed the art of forming a pleasing contour of a green site, and showed much skill in the designing and making of its accompanying bunkers, neglected to ensure the primary and most vital factor which is a sine qua non of turf culture—to wit—the correct physical constitution of the top soil indispensable to obtain porosity and fertility. Do not some of us remember how we were requisitioned to proceed out on the course and view one such green—all moulded and finished, except for the turving—how we were invited to behold its noble lines, pleasing undulations and bunker escarpments? How, after a few timorous and tentative criticisms which we were expected to make, and withdrew almost in the same breath—as they were summarily disposed of by the supreme authority—we all subsided into a chorus of universal admiration? And then we all slowly came grouping away, hypnotised, as it were with the idea of the future magnificence of our course, which would be the envy of our neighbours; and not one of the *whole blinking lot of us* ever thought of walking on to the hallowed green area to examine its soil constitution.

And this is not so many years ago! Fortunately, the result of the subsequent inquests to which all the interested parties have been called has been a coroner's verdict to the effect that the plea of divided responsibility would not, in future, be accepted. Happily there is more reason to believe that these bitter experiences have had a very salutary effect on the whole personnel engaged in course architecture and construction; but it is the duty of every executive green committee member to ever exercise a keen and watchful eye.

Then there is the *tragedy of agricultural misdirection.* I have visited and examined fifty courses during the last eighteen months, and on a goodly proportion of these one would wager to take the acid bent turf on the edge of some fairway, or even from the rough, and in less than two years to make it into greens better in every respect than the existing ones. The die-hard advocates of liming still refuse to acknowledge the evidential benefits of acidity and acid fertiliser treatment, and still tenaciously cling to their purely agricultural lore; they are oblivious of the fact that the same school of scientists who have given them the purely agricultural principles and practices of fertilisation have discerned that the needs of a golf course are a converse proportion, with the consequence that the die-hards have been left marooned, and, moreover, they are not aware of it.

But one gets trenchant, and it is not in keeping with the Christmas spirit of peace and good fellowship; rather if we turn on the rays of introspection we shall find *ourselves harbouring some such streak of conservatism.* Were we not taught at school to pronounce Cicero with both C's soft? Then the learned men discovered that they were wrong, and that this Roman philosopher was addressed by his countrymen as " Kikero." Don't we all chafe and writhe at the correct harder pronunciation, and want to refuse to believe that it really obtained? So being ingrained with the synonym lime=sweetness, the word "acidity" becomes a mental hazard.

What of the comedies? Is it not sheer farce to elect as chairman or convenor of the green committee gentlemen who have absolutely no qualification for the post? Yet this is often done generally because it is rightly regarded as a very honoured and responsible office, and it is *Mr. So-and-So's turn to hold it.* Would such a procedure be tolerated, or even thought of, in a successful industrial technical business? An analogy would be to put the cashier or traveller of a textile firm in charge of the dyeing department! What is the general sequence? The new chairman, full of the best intentions in the world, and ablaze with zeal, strikes out on his own. He is a prey to every fertilising vendor; and, with the individuality that has made his own business a success, usually decides that he will try something different to his predecessor. Thus our greens are treated, fed, and doped with a various succession of fertilisers and quack medicines. The result of the first applications, *aided largely by the vital urge of spring*, are hailed with delight, but evils come in their train that defy elimination. Nor should our green committee chairman be a man imbued with the " little knowledge that is dangerous "; such a chairman is capable of doing even more harm. The chairman of the future will be the man *who can only regard his post as tenable* when he imagines that his very bread and butter depends on his production of good turf, and that failure means unemployment.

The Suicide of the " Accumulated Generations."

BY NORMAN HACKETT.

IT may well be that readers of this page will be inclined to manifest a little irritation occasioned by the monthly doses of " acid treatment " meted out to them, but since it is meeting with a good deal of criticism, not to mention active opposition, from my friends of the seed and fertilising trade, and it is rather important at this time of the year that green committees shall not be confused or switched from this governing theory and its practices, both of which have the endorsement of our agricultural scientists, and are in the writer's opinion completely justified by results and natural evidence, it behoves one to meet comment with reply. Moreover, much of this adverse criticism is based on the works and text-books of these same scientists, and as far as pure agriculture and horticulture are concerned they still hold good to-day, but even then with some very material modifications; for instance, the principles underlying what is known as the base exchange (1) in soils (which includes lime requirement), and the constitution of the soil particles themselves, have been completely remodelled during the last six years, not to mention the most important discovery that fertilisation can and does take place *without the aid of nitrifying bacteria*. At the end of this article will be found the references whereby any critic or reader who wishes to take the trouble may verify these and other statements, Believe me, this acid condition and fertiliser treatment has not been formed haphazard by any set of quacks, but, if I may paraphrase a phrase, by the accumulated knowledge of generations of scientists (and, perhaps, the last ten years of the present generation has been the most fruitful), whose sole work is to unlock the doors of Nature's secrets; to pursue and establish the truth and to harness it for the economic good.

May I now reply to the points raised by Mr. F. G. Clavering Fison, F.R.H.S., in his article, "The Dangers of Soil Acidity," published in the February issue of "Golfing."

I agree that bacteria *are* essential for *nitrification*, but it is now recognised that strains of nitrifying bacteria exist (in addition to the anerobic bacteria, which can only live and function in a limed soil) which are capable of converting ammonia into nitrate under conditions of very high acidity. In this connection, I would refer him to a paper recently published by Olsen (2) in which it is shown that nitrification can proceed in a soil whose p.h. value is as low as 3.7, a degree of acidity, be it well noted, more than twice as acid as 4 p.h., which latter is the ideal objective limit to be attained by the so-called acid system of turf production. (N.B.—The p.h. table is geometric i.e., 3 p.h. is *ten times* more acid than 4 p.h., and *one hundred times* more acid than 5 p.h., etc.)

The writer at the present time has plots of beautiful turf composed solely of mixed bents, no weeds, clover, or worms, the seed of which was sown in a soil registering 3.8 p.h. (this degree was checked at the Bio-Chemical Institute, Cambridge University). Some weeks ago, on a grouse moor he found the most acid soil he has ever struck—3.56 (also determined by the electrical method at Cambridge, which is exact). Subsequently, half-a-sackful was put into four seed boxes, and sown respectively with mixed bent, red fescue, hard fescue, and aria flexuosa, *adding no lime or fertiliser whatsoever.* All have germinated and come along well, and show no resentment at their "unhealthy" and "infertile" habitat. We are now repeating this experiment, duplicating it with seed sown in an alkaline soil, for comparison.

But, to resume, although nitrates (the " available " form to which sulphate of ammonia is nitrified by the bacteria) are usually recognised as the customary form of nitrogenous plant food, it has been abundantly proved by Prianischnikow (3) that with the graminaceæ (grasses, etc.), especially, *ammonia itself is taken up direct* with far greater ease than is nitrate. Also, under the conditions under which rice is grown, nitrification does not occur, and the ammonium ion is absorbed direct.

It is not correct to state that " Nitrogen encourages the growth of the blades without developing the roots." Nitrogen is known to encourage the whole vegetative development of the plant. Are not nitrogenous fertilisers recognised as capable of producing marked increases in root crops? Root growth is merely a matter of observation. It is definitely established that if regular composting is combined with regular application of sulphate of ammonia, there is a marked increase in the root formation of the finer grasses. (Two factors contribute to this: Ammonia is held and absorbed by the top two or three inches of soil—in this respect it differs from nitrate of soda—consequently it is feeding the shallower-rooted finer grasses at the expense of the deeper-rooted pasture grasses.) They withstand drought extremely well, owing to the water-retaining properties of the humus that is incorporated in the compost, and the fact that the soil colloids are in the optimum physical conditions for water retention and aeration.

Mr. Fison's statement that the plant food in sulphate of ammonia becomes available all at once is scarcely in keeping with his earlier reference to the necessity for nitrifying organisms, and to the supposed effect of acidity in inhibiting these. If he and others would realise that the finer grasses can more readily absorb ammonia than nitrate, he would perhaps be less anxious about the fate of the bacteria.

Among other criticisms which have been put forward by opponents of the acidity theory are the following:—

(a) That pearlwort is encouraged by the sour conditions brought about by the systematic use of acid fertilisers. Hoylake greens are all alkaline. Mr. Norman Boase and myself, examining these together, agreed that they were 50 per cent. Poa annua and 50 per cent. pearlwort. I certainly do not know of any greens where pearlwort is so ubiquitous.

(b) " That the success of the acid theory depends on greens of bent and fescues. Many greens are not so fortunately planted." But a great number of clubs buy "putting green mixtures composed of the finer grasses only." The trouble of most clubs is that though planted, they have failed to remain the predominant grasses, and most of the evidence points to the old fertilising prescriptions as the cause.

(c) " The statement that the finer grasses are peculiar to lime-free conditions is disproved by the fields of ovina tenuifolia to be found on the South Downs." On the contrary the South Downs confirm this statement. I have received many samples of turf from off the South Downs; they were all composed of festuca ovina and agrostes all right, but very acid. One is quite aware that the sub-soil is highly calcareous, and rests on solid limestone rock. This is no unusual phenomenon, but one which the writer has pointed out many times. Only last week I received a sod cut from off the Marlborough Golf Links, on the Wiltshire Downs—is it very acid, 4.5 p.h.—accompanied by a signed statement from a geologist that this turf rests on 300 feet of solid limestone rock! (N.B.—The Romans discovered that such acid top-soil leached of its lime content must be renewed by lime from below to make it agriculturally fertile. Pliny records this in his writings.) Where this has been done *the results are disastrous from the golf turf point of view.* The last case in point is Lindrick Common Links (Sheffield Club), which the writer visited to advise a few weeks ago. These links have six inches of soil on solid limestone rock. The rough is still acid, and beautiful golfing turf; the fairways were, but acting on agricultural advice they limed their fairways four years ago. The whole original character of this limed turf has gone; the resilient mat of acid fescue and bent turf has completely disappeared, and a complete transition to the agricultural grasses has taken place, accompanied by daisies and plantains galore, and a mass of worm casts. As I went out for a round with Mr. Bernard Wragg, an ex-Yorkshire champion, he told me to leave my brassie in the club house! The committee informed me they would give hundreds of pounds to undo the error. If any club is contemplating liming their fairways, for goodness sake let them pay a visit to Lindrick first. Innumerable cases, such as this, have come under my notice. For instance the liming of the course at St. Andrews, round about the area of the 1st, 18th, 2nd, and 17th, on which last autumn, they used six tons of worm killer, and then only palliated the trouble; in contradistinction, the Elysian fields (14th), with an acidity of p.h. 4.5, are worm free, almost entirely weed-free, and present a glorious sward of the finer grasses.

(d) " Bents and fescues will thrive in alkaline as well as acid soils." Except in the one case of red fescue, as Cumberland turf growing in its own habitat, where it is periodically inundated with sea water, the salt inhibiting every other species of grass, the evidence is to the contrary. (In this connection further note Rothamstead references, which both cover the statement that " Sulphate of ammonia coarsens grass," and deal with the query respecting the transition of the grasses as the soil becomes either acid or alkaline.

It is, however, when critics adduce the Rothamstead experiments as an unbiased and infallible prop to support their contentions that the prop gives way, and they *fall on their own swords*.

When the writer's attention and interest was first roused by reading the American research findings, and he was still unconvinced of their validity, he proceeded to Rothamstead to inspect these famous plots and consult the staff as to the inferences to be learnt therefrom. He came away fully convinced that the Rothamstead experiments (4) confirmed the acid fertilisation theory for the finer grasses.

Now it is perfectly obvious that they cannot support both sides of the argument.

At this point I want to be perfectly fair, both to my critics and readers, and will, therefore, restate the premises of our argument.

Mr. Fison claims that liming and the use of a complete fertiliser (i.e., one that contains the three elements, nitrogen, phosphorus, and potash) is the best possible treatment for golf turf requirements. I absolutely and definitely disagree as regards liming. I agree that *some* phosphorus and potash is necessary—I have never said anything else—but my critics will persist in either ignoring or veiling my oft-repeated statement, that the phosphorus and potash contained in the compost has been proved by the American researches to be *sufficient for the needs of the finer grasses*. To give more than is necessary only encourages the coarser grasses at the expense of the finer ones.

Having made this point clear, let us now examine the extracts put forward by Mr. Fison on the Rothamstead experiments. (5)

Space will not allow of it in extenso, but I will take two plots—the sulphate of ammonia *only* plot, and the best one he puts forward on behalf of his case, viz., complete manure.

Fertiliser used.	Percent. of Clovers.	Percent. of true grass.	Percent. of weeds.	Plot No. at Rothamstead.
Nitrogen (as Sulphate of Ammonia.)	1.4	77.6	21.0	5 (1)
Complete Manure (Nitrogen as Sulphate of Ammonia.)	1.3	91.2	7.5	9, 11 (1) 11 (2)

I have added the last column, which denotes the actual numbers of these plots at Rothamstead.

There are three plots of the complete manure (nitrogen as sulphate of ammonia) treatment; they only vary as to quantities of complete manure, and for our joint purpose any one or the three can be taken. The data also apply to the limed halves of each plot. The percentage of clover, *TRUE* grasses and weeds are as Mr. Fison states, but here I cannot resist putting the word "*true*" in italic capitals, for I am going to drop a bomb. Of the 91.2 per cent. of true grasses, 82 *per cent.* is composed of two grasses only, in about equal proportions, *Alopecurus Pratensis* (Meadow Foxtail), and *Arrhenatherum Avenacea* (False or Tall Oat Grass). The former grows three feet high; the latter four feet high. After cock's foot and perhaps Timothy, they constitute the heaviest and most prolific hay grasses, excellent for agricultural purposes, but not to be thought of or tolerated on a putting green. Certainly no seed merchant would dream of putting them in his putting green mixture. The remaining 9 per cent. is also made up of unwanted grasses, there being *no fescues at all* in all three plots, and Agrostis vulgaris (bent) to the extent of only 2.36 in one of them! !

Now let us turn to plot 5 (1)—sulphate of ammonia only (unlimed).

There is no table in the Rothamstead book giving recent actual percentages of the individual species of grasses of this plot, but it is stated that the fescues form about half the total crop, and Agrostis vulgaris "is plentiful." If we compute the latter at not more than 15 per cent., it gives 65 per cent, out of the total of 77.6 per cent. as composed of the finest possible grasses. Of the 21 per cent. of weeds, sorrel indeed accounts for the major portion, 12.24 per cent. in 1919; in 1914 the grasses were 86.39 per cent., and weeds 13.15 per cent., and of the latter, sorrel was represented by only 1.34 per cent. As is mentioned, the amount of sorrel varies with the seasons favourable or otherwise for its growth.

Further valuable and illuminating information is disclosed by a closer perusal of the history of the plot. Like all the other plots, treatment began in 1856 (at this initial period, an area possessing the *same character throughout* was divided into the plots). Sulphate of ammonia only was given to this plot until 1897, when it was stopped, and no fertiliser of any kind applied since. In 1877 the table gives:—

Grasses, 94 per cent. Clover, .2 per cent. Weeds, 5.7 per cent. Of the grasses, only 10.4 per cent. were other than fescue and agrostis—the latter being represented to the extent of nearly 30 per cent. At this period the plot would have appeared to constitute the basis for ideal putting turf. From the agricultural point of view it was *then* regarded as "infertile," if not "sterile," two words which have a very different meaning in agriculture and golf turf nomenclature, respectively.

It took from 1856 to 1877, *twenty-one years*, to arrive at this most desirable state; surely the inference is that golf clubs shall not be frightened or deterred by such statements that sulphate of ammonia makes soil infertile or "coarsens the grass." From 1877 to 1897, when treatment ceased, there appears a gradual increase in sorrel. This may be due to the increasing of acidity over the desired border line, but more probably to the entire depletion of phosphorus and potash from the soil; such removal is provided for in the so-called acid-fertilisation treatment by the phosphorus and potash contained in the compost.

In any case we need not worry at all at the present about these two fertilisers. Let us, as in the case of this plot, *achieve the transition to the finer grasses*, and when this occurs, it is *time enough* to determine their phosphorus and potash replenishment needs.

Neither need one spare a thought to the sorrel or spurrey content; you will not find them in acid turf, because they are "bleeders," and close cutting kills them; they are merely *bogey "red herrings"* in the argument.

There is further one very important fact to be taken into consideration in studying the Rothamstead results. They are all based on the *total herbage removed by a reaper*, once and sometimes twice a year, in other words hay crops, where every species of grass and weed is allowed to grow to maturity. When cut and dried, hay samples are taken from each plot, and a staff of girls, superintended by expert botanists, sort each grass stalk and weed into its proper category; these are then weighed, and the individual percentages ascertained.

It must be obvious that such percentages do not *correlate with area or surface percentages* that would obtain if such grass were kept continuously in putting green or fairway condition. The actual "floor" space taken up by a given weight of the full-grown finer grasses would, on a modest estimate, be a quarter of that occupied by the same weight of full-grown coarser grasses. A given weight of full-grown sorrel will again represent far more area than the same weight of ripe fescue or agrostis. Nor is any account whatever taken of weeds that entirely escape the reaper, pearlwort, daisies, etc. These two latter are not mentioned from cover to cover in the Rothamstead book. A careful study of these latter facts by the reader will enable him to see that *in every case* the area occupied by the finer grasses will be much higher than the hay percentages recorded. Moreover, it is common knowledge that close cutting or close grazing entirely modifies the effect of manures on these percentages. In my opinion the Rothamstead experiments present a *striking and startling vindication* of the Acid Fertiliser Treatment.

The Future of Greenkeepers.

ON a subject of this description it is dangerous to talk, and still more dangerous to write. One hears and reads so much about acid treatment of soil that it would appear that the art of greenkeeping has been reduced to absolute simplicity. All that is required according to American experts, is a plentiful supply of sulphate of ammonia, a big compost heap, a man to mix and distribute, then all troubles automatically disappear; weeds, worms, and even our dear old friend Daddy Longlegs are unable to withstand this treatment. We are also told that lime can be for ever dispensed with as far as its use on a golf course is concerned. While I do not intend to comment upon the merits of this particular subject, I venture to predict that weeding forks, wormkillers, pest destroyers, and renovating mixtures will still be required several years hence.

I think the leading minds in golf are apt to accept too much of the theoretical, or even scientific, advice of outside authorities rather than the practical knowledge of the greenkeeper, which, in a great many cases, has taken several years to attain.

We read week by week, or month by month, discussions in the golfing papers relating to greenkeepers—to take at random one or two examples: "Sheep on golf courses, Rabbits (I mean 4-legged ones), Hints to greenkeepers, etc."—and yet one rarely sees the name of a greenkeeper taking part, and it can be readily understood, in a great many cases, it would be unsafe for an individual greenkeeper to express his personal opinion in the press, when it might be contradictory to that of his club secretary or members of the committee.

I venture to suggest, however, that our Association, through the medium of its advisory committee, could, from time to time, make its weight felt in some of these press discussions. There need be no names mentioned, merely " Advisory Committee, Greenkeepers' Association." It would at least let the golfing world know we do possess an advisory committee. I really do not know its composition, but I feel sure the concentrated brain power of the members would be able to formulate articles suitable for printing; and, doubtless, we should see advertised very shortly, in perhaps one of the leading golf journals (if they were approached), " All queries regarding greenkeeping will be answered by the Advisory Committee of the Greenkeepers' Association." This would sound much better than answered by Mr. So.-and-So, who is, perhaps a golf professional, newspaper man, or enterprising salesman. And, lastly, taking a very big peep into the future, some day we may have the pleasure of playing our annual tournament on a course which has been designed by our own Advisory Committee.

Lecture.

BY W. HERBERT FOWLER.

WHEN Mr. Smithers wrote to me, some little time back, and asked me if I would come and give a lecture to the Greenkeepers' Association, I thought at once what an unsuitable word " Lecture " was in connection with such a body of men. Then I saw that he asked that I should give some hints as to golf course construction, and I hoped I might possibly be able to give some hints which would be useful. So here I am, rather nervous, but sure that you will forgive any shortcomings on my part; for I can assure you this is the first time I have appeared as a Lecturer. No; I remember that is not quite true, for many years ago I did read a paper to the members of the National Chrysanthemum Society, on the growing and exhibiting of Japanese 'mums. Before I embark on the practical side of golf course construction, I think it may interest some of the younger members to hear of the beginning of my golf experience, and how the game was played in the late seventies, and how the courses were kept.

It is just 50 years since I first saw a golf course, and it was the first of our seaside courses which gave me the thrill of hitting a sitting ball. At that time I was very keen on cricket, but I had heard of a game called golf which was popular in Scotland, and as I was living in the West of England, and in the course of my business had to go to Bideford, it was only natural I should enquire about the links which I heard were situated at Westward Ho! Further, I was very keen to see the place made famous for ever through the genius of Charles Kingsley. Among those I was meeting in Bideford was Capt. Molesworth, R.N., affectionately known to a wide circle of friends as "The Old Mole." I asked him whether he could put me in the way of seeing the game of golf played, when he at once invited me to go out with him the very next day and have a try at the game myself. Of the drive out to the Pebble Ridge Hotel, with the Captain driving tandem up and down those steep hills, I have a lively recollection. However, we arrived safely, and then I got my first view of a tract of land which was to give me so many glorious days of pleasure in the coming years.

The club house was a small tin hut at the foot of the great ridge, and it had to be hurriedly moved in the course of the next two years. The course then was chiefly amongst the big sand hills, and nowadays would be considered impossible on account of the numerous crossings and the shortness of many of the holes. Greenkeeping, as now understood, did not exist; there were no sand boxes, no cases for the holes, and the flags were tacked on such shafts as were too crooked to make golf clubs. The result was that the wind soon made the holes ragged and any shape but round. There were no recognised tees, but the rule was to tee up three club lengths from the hole. Mowing machines were unknown there, and, as a matter of fact, they have never been used on the fairways to this day. Of course, machines came into use some time in the 'eighties for the greens.

Of course, the implements matched the greenkeeping. The play clubs were long and very whippy, the irons very clumsy, and wooden putters predominated. The balls were all made by the professionals, and did not last long. Nor did the wooden clubs for that matter. But in spite of all these disabilities, or, say, rather what the modern golfer would consider to be disabilities, some very fine golf was played by Horace Hutchinson and Arthur Molesworth, amongst the amateurs; and by the three brothers Allen, who looked after the wants of players over these historic links. One of them was Jimmy, and he was one of the best players of his day, and played several big matches under the ægis of the Old Mole. Unfortunately, he died young and before he came to what should have been his best. He had the power of hitting a full shot with wood, which went a long way, quite low and then soared and fell dead and with no run whatever. This was a great shot in the days when there were many cross-hazards.

The following 12 years saw a gradual change in the game, and an increasing interest in it amongst game players in England. Somewhere about 1886 the Royal St. George's Course came into being, and then the English movement really began. From then onwards courses began to rise in rapid succession all over England, and many dreadful things were done to otherwise attractive pieces of ground. In order to save trouble and expense, many hazards of the steeplechase bank type were built, and nothing less artistic can be imagined than those to be seen at Mitcham and other early courses. At the end of the 'nineties people began to realise that courses could be made which need not of necessity be a blot on the ground on which they were laid out, and perhaps it would be fair to say that Woking was the first of the really good inland greens. Sunningdale and Walton Heath followed in rapid succession, and then began a race to see who could make the best of new lands and produce the real thing inland. At the present time I think one can say that the seaside greens have no predominance over those made inland, and this is especially the case with those on heather land.

In talking to you gentlemen on the subject of construction, I should like to emphasise the necessity of studying the artistic side of construction. In order to get a good idea of what this means, it is only necessary to see what Nature does in the way of making slopes. Water and wind are the two great elements which have produced slopes and mounds which are an object lesson. There is one test of a good slope from a bank. One should never be able to point to any spot where the slope ends. There is a lot more in this than one would at first imagine. The construction of greens and bunkers has been enormously helped of late years by the use of scoops, drawn by horses. Formerly, when one was making a green, especially those of the plateau variety, one had to bring the soil by barrows or carts, and dump it down, and afterwards get the slopes or levels by means of the rake. The results were never nearly so good as when scoops are in use. In addition to the better results, there is the fact that the cost is very greatly lessened. In fact I think it is certain that one can make a course now for less money than one could before the war; and this in spite of much higher wages and dearer horse hire. Of course, when one says this it must be admitted that the standard asked for is much higher than of old time. Let us suppose we are going to make a plateau green, and that the soil is of a sandy nature. The first thing is to peg out the outside lines, marking the shape of the green. Then one pegs out the size and shape of the surrounding bunkers or grassy hollows. The men take the scoops, and begin by lowering the bunkers and hollows, the scoops will fill themselves, and, as soon as full, the scoop is taken on to the ground where the green is to be, and emptied where the man in charge indicates. In this way it very soon begins to show its contours, and all the time the sand or soil is being brought on to the green the weight of the full scoops is consolidating the green. The scoops make the slopes down into the bunkers in a way that no digging can compete with, and they also make splendid mounds and hollows in the green itself. It is an object lesson to go to a course under construction, and to watch the result of scoops at work.

There is some difference where the soil is of a nature which is too solid for the scoop to cut in of its own weight. The use of single-horse plough is then brought into use, and as the bunkers get lower the plough is used as soon as the ground it had loosened before is all taken away. Of course all this work requires experience before the best results can be obtained; and this is also true of the horses as well as the men. After a time they get very handy. When I was making a big course in California, I had a lot of moving to do, and there we did it with large scoops, with six mules to each scoop. It was interesting to see how clever they became, and, as the soil was sandy, the amount of stuff moved in a day was truly wonderful.

As a rule, the chief constructional work that greenkeepers have to do is in connection with alterations to bunkers, and the making of new ones. Unless the work is of an important nature the use of scoops is hardly necessary, though I think all courses ought to have one on the premises. If they are not used the old plan of barrows comes in, and then it is the rake which has the final say in making the slopes. The use of this tool requires much practice to make a good job of the business. There are several things worth remembering in making banks. In the first place all slopes behind the bunker face should be as long as the ground will allow. In many courses the water level is so near the surface that going down any real depth is impossible, and in these cases there is nothing for it but to build up behind the bunker. Of course, where possible, there are no bunkers so good as those which are really deep. But here again one is faced with another problem: " What is one to do with all the stuff that comes out of a really deep bunker? " This is a question which one can only decide on when one sees the ground. Speaking generally, some of the sand or soil can be put at the back, and sloped gradually to join the ground level, but most of it should go on the side of the bunker away from the fairway. This, of course, where the bunkers are on the sides of the course. Where they are in the middle of the fairway one can make a series of mounds in connection with the bunkers, and in this way there will be a saving of sand, and the general result will be very satisfactory.

The sand question is one of the greatest importance, and in all cases where sand has to be bought, and brought from any distance, the formation of bunkers is a very serious problem. Unless great care is taken to minimise the actual amount of sand space, there will be great waste in the amount of sand to be bought in the first place, and, in the future, for renovation purposes. If hills are incorporated with the bunkers, it will be found possible to have small pots where all the balls will gather, and in this way the amount of sand required will be very small. It will, however, be necessary to keep the grass on the sides of the hills short, so that balls will not remain on them, but will roll back into the bunkers.

In making greens, there are several important things to remember. In the first place, greens are intended for use as places where putting is to take place, and, in my opinion, any very bad slopes are quite out of place. On the other hand, no putting greens should be perfectly flat, nor should they be perfect squares. All greens should have slight waves in them, and these waves should be irregular in shape. In making a green one should always study the drainage question, and, if possible, all water should be able to find its way off the green, so that casual water should be reduced to a minimum. The more I see of golf and golf courses, the more I am sure that all putting greens should, as far as possible, be island. That is to say, that they should be apart from the rest of the ground in their neighbourhood. When making a new course this is comparatively an easy matter, as one can take out soil from the sides, and raise the floor of the green. In the case of a hole where the second shot is to be played with wood, it is clear that there must be an entrance to the green, or it must be so long that there is room for the ball to run and stop, after carrying the defending bunker in front of the green. The 18th green at Walton Heath is a good example of a hole of this character. Where it is considered necessary to alter an existing green it is more difficult to get the above results, and in some cases it will not be found possible to go to the expense of making an island. In these cases, the shape of the green should be made by mowing. One goes to course after course, where one sees greens being cut perfectly square. This is all wrong, and I do hope greenkeepers will soon give up cutting them in this way, and will mark out their greens in bold curves, leaving the grass round them semi-rough. The general appearance of the course will be immensely improved if this is done.

In laying out a course great care should be taken to see that the one-shot holes are of the best possible quality. Personally, I think a course is never a good one unless this class of hole is really first-class. Now that inventors have so spoilt the game by making it possible to hit the ball to absurd distances, the only thing a golf architect can do to get decent two-shot holes is to increase the number of holes of the one-shot variety. There is a limit to the number of yards which a course can have. I am no believer in making a course so long that it becomes a weariness to most of those who have to play on it, and it must always be remembered that the rank and file of golfers are those who do not hit the ball immense distances, and yet they are the people who keep the courses going. In my opinion, a course of from 6,300 to 6,500 yards is amply long enough, and the latter should not be exceeded. For all championships I think there should be specially laid-out couses, one in England, and one in Scotland, and then one could have a course which would be long enough to test even the biggest hitters. Some day this will, no doubt, be made, but until it arrives I do hope courses will be kept to a reasonable length.

I do not propose to touch on greenkeeping, as I know you are all more or less experts in the science; for to-day, greenkeeping is a science. But there is one thing which I do believe is sound, and that is in dressing little and often, and mostly with a compost made from rotted turf mixed with horse manure. I find that this method not only is the best fertiliser, but it keeps the surface of the green free from small holes. Artificials should only be used when the soil has been analysed, and what is wanted has been decided by a competent chemist.

For heavy soils, I am a great believer in the use of charcoal. But when I say charcoal I mean rough cubes about the size of the end of one's little finger. The charcoal should be spread over the green in spring and autumn when the grass is growing rapidly, and rolled in lightly every morning. This should be done twice a year for three or even four years' running. The result will be apparent, not only in the extra firmness of the floor of the green but also in the improvement in the drainage. It also has a deterrent effect on the working of worms. The best place to get this charcoal is from Messrs. Walker and Sons, Hyde, Cheshire. The charcoal they send out has been used in some chemical works, and the result is that what is left in the charcoal has some manurial effect. At any rate it turns the grass a deeper colour of green.

In conclusion, I should like to say that I fear this lecture, or friendly talk, may strike you as being very dull and wanting in interest. The fact is that golf designing is one of those businesses which is very difficult to put down on paper. It is mostly a question of imagination and long experience, and making the best of the features of every different piece of land one comes across.

I remember when Mr. Macdonald came over here from America he brought a surveyor with him, and he intended to take elaborate measurements of some of the holes which are generally reckoned to be the best in the British Islands. He came to Walton Heath, and we had a long talk together. He explained to me all he intended to do, and asked my opinion on his scheme. I ventured to tell him

I thought he was entirely on the wrong tack, and that what he should do was to study our best holes and see why they were good, and then go back to America and try to incorporate those ideas in courses on the other side. However, he was set on his plan, and went back with all his plans and drawings. The result was a good course laid out at Southampton, Long Island, but no one could possibly recognise the holes as being copies to scale of the ones from this side.

There is one great difficulty in laying out which I believe all golf architects must suffer from; and that is the difficulty of never repeating one's self. But it is a great mistake for a golfer to be to say, " Oh! look at that green, it is exactly like the 3rd at such and such a course." However, the main thing is to make good holes, and to be very careful not to spoil the look of a bit of ground.

I shall be delighted to answer any queries any of you may care to ask me, and I should like to say how much I appreciate your asking me to come and meet you.

Herbage of Golf Courses, and Methods of Identification.

Lecture given by Mr. A. F. Wingfield of Messrs. Sutton & Sons, Reading, to the members of the Golf Greenkeepers' Association.

DOUBTLESS, all among you from time to time desire information in regard to the commoner types of vegetation, especially grasses, found growing on golf courses.

With reference to the identification of grasses, it is essential to remember that there are over 130 varieties in Britain, and in the main the numbers of species which are found on first-class courses are few in proportion to the total.

The first thing to do in studying grasses is to obtain a knowledge of the different kinds, habits, and uses. Before this can be done it is essential to become familiar with the general structure and purposes of the different organs. In this connection special attention must be given to those points upon which the classification of grasses is based. In collecting specimens, it is necessary to obtain the root growth as well as leaves, stems, flowers, and seeds, as in dealing with the vegetative organs, which may be described as the first section, these characters must be studied. The second section of the morphology of grasses deals with the floral organs, which consist of the flowering culm with the more or less branched collection of flowers borne upon it, and forming the inflorescence, A few typical species should be obtained, and, of these, couch grass and sheep's fescue represent two well-known types. In the case of some grasses, such as couch grass, the roots are produced at every node on the underground creeping stems, or rhizomes, as they are termed. Almost all grasses have fibrous roots, but in a few species the roots are tough and cord-like. Poa pratensis (smooth-stalked meadow grass) has creeping roots and fibrous ones at the nodes.

The flowering stems of grasses are termed "culms." All annual grasses have only one kind of stem, but as already stated some perennial species, such as couch grass, have underground stems as well. The flowering stems are hollow, except at the nodes or joints.

Agrostis and Poa trivialis possess thin surface creeping off-shoots or stolons, similar in nature to those of the strawberry plant. Such grasses are said to be stoloniferous.

As to leaves, each leaf consists of two parts, the lower portion surrounding the young shoot or culm, which is called the sheath, and the portion called the blade. The sheaths are attached to the stem at the nodes. In the case of some species they are marked with lines, and such grasses are known as having a striated sheath.

The sheath, when it forms a tube enclosing the stem, is said to be "entire." When the margins of the sheath overlap one another, the sheath is said to be "split."

When the blades are folded in the bud the shoot appears flattened, and by cutting the specimen across with a sharp knife it may be easily determined whether the leaf blades in the shoot are folded, or rolled as when the sheaths are round. In the case of couch grass, although the sheath is split, the leaves are rolled. Soft brome grass has entire sheaths, and cocksfoot is a specimen illustrating the folding of the leaves. As you are probably aware, the sheaths of cocksfoot have acute edges or keels.

One interesting point in regard to the sheaths of some grasses is that at different periods of growth they become coloured, either all round or in the veins only.

The blades of grasses vary in shape considerably. Some, as sheep's fescue, never unroll, whilst others are wider in the middle of the blade than they are at the end. The tops of the leaves of the Poa family are hooded.

Some leaves are ribbed, and in certain cases these ribs are situated on the upper surface. Sometimes, when the mid-rib is prominent below, it forms a keel from the bottom to the top of the leaf, as already mentioned in the case of cocksfoot.

At its base the blade often has claw-like appendages which clasp the stem. These projections are called ears or auricles, and provide an important method of identification.

The ligule is a growth which partly surrounds the stem or sheath in some grasses, at a point where the blade joins the sheath. It may be long or short, ragged, pointed, or blunt. In some cases it is found occurring as a tuft of hairs.

Other points of interest in identifying grasses are the position of hairs and whether they occur on the plant; also the colour of the foliage.

It is too intricate a matter to deal with the floral organs fully this evening, but, briefly, the flowers of all British species (with the exception of sweet vernal) have three stamens and a pair of stigmas. The boat-shaped scales which enclose the ovary and stamens are called the paleæ. The outer paleæ frequently bear an awn. In identifying such species of grasses this awn (or in some cases the presence of hairs on the seed) is very useful.

In the identification of grasses when they are not in flower, it is essential to examine specimens in the following order:—

1. Determine whether the leaf blades are rolled or folded up in the shoot.
2. Is the species smooth or more or less hairy?
3. Look at the ligule if one is present.
4. Ascertain whether there are any particular markings on the sheath, leaf blades, or stem.
5. Examine the root.

In regard to No. 2, if the grass is hairy it must be noted whether the hairs are long or scattered, or confined to the ribs, leaf margins, etc. For instance, one grass, Timothy, has deflexed teeth on the edge of the leaf. In three of the same species of Poas, namely pratensis, trivialis, and annua, the ligules differ. In the first it is blunt, in the second it is long anad glossy, whilst the ligule of Poa annua is long white, and conspicuous. In Triodia decumbens (heath grass), a variety which has stringy roots, the sheath is hairy, whilst the ligule itself consists of a tuft of hairs. In Molinia cœrulea, the ligule is either short or consists of a tuft of hairs.

It is essential to examine the ligule of the uppermost leaf, as in some species the ligules of the top and bottom leaves are not always the same in regard to length and breadth.

Sometimes the auricle is small, and more like a ledge-like projection at the base of the blade.

When naming grasses from the flower, it is essential to note whether an awn is present on the outer paleæ. Should one be found it must be noted whether it is at the top or nearly so, or whether it is dorsal or at the bottom.

In regard to seed, it is, of course sometimes difficult to the purchaser to identify individual seed of some of the grasses. The awn is often lost in cleaning seed by machinery. This applies to Poas, as, although there is a certain amount of hair on the seed, this is to a great extent lost in cleaning operations. In the case of tall oat grass, when the seed is ripe the outer palea of the lower flower bears a twisted awn.

The numerous species of British grasses occupy situations varying from old walls and sandy places to swamps, and some even grow in the water itself. Phragmites communis, a tall reed-like grass, six or even ten feet high, grows on the river banks, whilst Glyceria fluitans grows in water. Poa aquatica is found growing in the rushes by the sides of rivers.

Most grasses have a decided preference for certain conditions as regards soil, moisture, degree of shade, etc. Some species prefer stony situations, waysides and rocky places. Poa rigida may be found growing on the top of walls, and Festuca myurus, Hordeum murinum, and Poa compressa like dry situations.

Herbage on golf courses under certain varying climatic conditions does undergo changes, and I believe that in some seasons one particular kind of weed is more prevalent than in others. You have all, no doubt, been aware of years when dandelions have predominated, and of another year when daisies seemed more conspicuous. It is fortunate that weeds are practically obsolete on the putting greens of all first-class courses to-day. Clover, however, is often found, and this is a plant which varies in growth in different seasons.

The problems with which a greenkeeper has to deal sometimes appear simple to an amateur; but, as in the case of other matters connected with scientific accomplishments, much time must be devoted to experimental work and continuous observation before Nature will yield up its secrets.

Types of soil will, of course, play an important part in connection with vegetation growing on a golf course. On clay soils the vegetation is usually of a coarser type. The weeds grow stronger and more freely, and appear to flourish under conditions which are not the same as on courses which are on sand. These grow the finer fescues well, and different species of the agrostis family. Agrostis canina, of which there is no really pure seed in commerce, grows freely in certain sandy districts with other members of the same family.

The actual species of plants which grow in different localities are determined primarily by temperature. Some grasses prefer warm and dry conditions; others grow best only where the temperature is low. With our temperate climate, we do not have to worry very much over the drier conditions such as are found in India and other countries, and, consequently, I think we may claim that our courses, and particularly the putting greens, are in the main the finest in the world.

All plants absorb water and give off water vapour from their leaves. The beech tree is an example which gives off a considerable amount of vapour by transpiration. Plants which do this are known as hydrophytes. Those, such as pines, shrubs, and herbs like coarse heather, and many grasses, which do not give off water vapour to a large degree, are known as xerophytes. The fine needle-like leaved grasses, such as sheep's fescue, red fescue, and fine-leaved sheep's fescue, indicate that they belong to the xerophytes.

Water, therefore, plays an important part in plant life. In wet districts, forests are found. Where the water supply is less plentiful, grassland takes the place of forest, and where there is the extreme minimum of water available we find sandy deserts, which grow little vegetation.

The fine grasses can be persuaded to grow together on sandy soils when water is provided, but the coarser sand grasses, such as sea lyme grass and marram grass plant themselves, and help to reclaim the desert to grassland without the aid of artificial watering. Certain grasses will grow under wet conditions, but these are usually rank in growth, and not suitable for pleasure turf. When the soil does not retain moisture, it is necessary to add humus or organic matter to bind the soil, and when this is done to a sufficient degree, practically any form of useful plant life may be grown. The pines which grow in the heather regions belong to the drought-resisting section, and are found on the best inland courses, which carry such wonderful turf for winter play. Greenkeeping on such courses is not easy, and the upkeep of these forest courses is somewhat more difficult than that of seaside links.

On peaty soils, by manurial treatment and drainage, it may be found that some courses lose their xerophytic flora, and become like meadowland. This is, of course, not desirable, but it emphasises the need of keeping the soil in such a condition that it favours only the ideal golfing grasses.

In waterlogged soils, roots have very little oxygen available, so that they are apt to die of suffocation. Only a few British plants can live in marshy soil and mud, and such species usually have feeble roots, and possess large air spaces in their stems and leaf stalks, so that oxygen can be pumped down to the stems and roots in the mud.

The following notes concern a few of the more common grasses:

POA PRATENSIS (Smooth-stalked Meadow Grass).

This is a common specie in the British Isles. It is a perennial. The sheaths are entire, and the leaf blade, which is keeled below, terminates with a hooded point. As already stated, the ligule is short and blunt, and sometimes almost obsolete. The plant is not hairy and has no auricles.

The most certain distinguishing characteristics are the two faint white lines, one on each side of the mid-rib, that are plainly visible when the blade is held to the light. Another proof of identity is the curiously-hooded nature of the apex of the leaf.

LOLIUM PERENNE (Perennial Rye Grass).

As you are aware, this grass is not suitable for putting greens. It is often found on the fairways. It produces bents which are only with difficulty kept under by the mower. It is not a hairy grass, and its lower leaf sheaths, just below the ground, are red in colour. The ligule is extremely short, and the upper surface of the leaf blade possesses well-marked longitudinal ribs. These can best be seen when a leaf is cut across with a sharp knife and a section examined with a lens. It should not be confused with crested dog's tail, which has yellow to yellow-brown leaf sheaths, a concave or not quite flat leaf ,and the same prominent ribs on the upper surfaces of the blades. The leaves in both these varieties are folded in the bud, and the shoot appears to be flattened.

Perennial rye grass must not, of course, be confused with Italian rye grass, which also has pink leaf sheaths. In the case of Italian rye grass, the leaves are rolled in the bud, and the shoot is round.

FESTUCA OVINA (Sheep's Fescue).

This grass is believed by some people to be the same as hard fescue, but it is totally different, and true seed is exceedingly difficult to obtain. A large quantity of the beautiful downland turf is composed to a considerable degree of sheep's fescue. It grows in large tufts, the leaves are firm and rigid, and it retains its vivid green colour even in dry weather. Sheep's fescue, as well as the fine-leaved sheep's fescue, forms fine quality turf for putting greens. Both these varieties are distinguished by their slender needle-like leaf blades. They have no ligule.

ALOPECURUS PRATENSIS (Meadow Foxtail).

This is a perennial agricultural grass, which blooms early in spring. It produces a large amount of leafy herbage, and is found growing freely on good soils near the large rivers of England.

Foxtail may be mistaken for Timothy, but as the last-named grass comes to maturity much later, there should be little doubt about identifying it. The ligule is short, and the leaves are long, broad, and prominently veined. Sheath dark brown or violet-coloured, at the base of the plant.

TRITICUM (AGROPYRUM) REPENS (True Couch Grass).

The leaf sheaths of this grass are split. The lower ones are usually hairy. The blade is rolled in the shoot, tall, long, and rather thin. It is broader in the middle, tapering to an acute point and narrowing below. The upper surface of the leaf blade is sparsely hairy, and the lower surface is slightly keeled near the base. The auricles of triticum are prominent, narrow, and pointed. The ligule is very short, blunt, and finely fringed.

FESTUCA ARENARIA (Creeping Fescue).

This is the seaside form of red fescue, and a very valuable species for fine turf. It has a creeping root, and like the remainder of the fescues, the ligule is either much reduced or entirely absent. This point, by the way, helps to determine the difference between Aira flexuosa, a variety with a well-developed ligule and with needle-like leaves, the same as the finer fescues. Seed of Aira flexuosa is usually of poor germination.

AGROSTIS VULGARIS (Creeping Bent).

A valuable grass for golfing turf, especially on light soils. It should not be confused with Agrostis alba, of which seed is available at a comparatively low price. It is very difficult to identify the seeds of these two varieties apart, and even a trained botanist can only distinguish them with certainty under a high-power microscope. Agrostis vulgaris is distinctly creeping, though sometimes it assumes a slightly tufted appearance if neglected. The leaves are narrow, short, tapering gradually from a little above the base to the top, and the ligule is short and obtuse. The creeping stolons which give rise to new plants, the prominent rounded ridges on the upper leaf surface, and the other factors just mentioned, should help you to identify this grass. Agrostis canina is known as brown bent grass. You have doubtless read something of this variety. It is very near to Agrostis vulgaris, but distinct from it by the following:—

> The ligule is long and acute, and the lower leaves almost needle-like. The outer palea bears a fine dorsal awn as long as itself.

AGROSTIS ALBA (Fiorin).

This may be recognised by its long, pointed ligule, and wider leaves than those of Agrostis vulgaris. It has a more distinctly creeping root than the latter.

ALOPECURUS GENICULATUS (Marsh Floating Foxtail).

This variety is found growing principally on the edge of ponds and in other wet places. The leaf sheaths are cylindrical. It is a perennial weed grass.

YORKSHIRE FOG (Holcus lanatus).

Yorkshire Fog is a pernicious weed grass, chiefly met with on courses formed on light soils. The light green sheaths and leaves are thickly clothed with short soft hairs. The most noticeable feature is the pink veins present in the lower sheaths. The tufted habit of growth should also be observed.

Notice to Members.

The Executive Committee wishes to make it known amongst its members that a copy of this "Journal" is sent to all members, post free, who are not in arrears with their subscription.

W. H. SMITHERS.

The Golf Greenkeepers' Association Employment Bureau.

Members out of employment or desirous of changing their situations should apply to the Hon. Secretary, who will put them in touch with Golf Clubs requiring Greenkeepers as occasions arise.

Lending Library.

The Executive desire to announce that a Lending Library has been started, from which members may conditionally borrow books on subjects appertaining to Greenkeeping.

The books available for borrowing at present are as follows, with the postage to be prepaid by the borrower as stated :—

"Fertilisers and Manures," by Sir A. D. Hall ...	Postage	6d.
"Agricultural Botany," by John Percival, M.A., F.L.S.	,,	6d.
"Vegetable Mould and Earthworms," by C. Darwin	,,	6d.
"Fertilisers," by E. B. Voorhees.	,,	6d.
"Grass," by A. J. Macself.	,,	6d.
"Elements of Botany," by Sir Francis Darwin.	,,	4d.
"Weeds," by R. Lloyd Praeger.	,,	3d.
"Chemistry of the Garden," by H. Cousins. ...	,,	3d.
"Inorganic Chemistry," by E. C. C. Baly. ...	,,	3d.
"Botany," by Joseph W. Oliver and W. B. Grove.	,,	3d.
"Chemistry," by W. A. Tilden.	,,	3d.
"Golf Architecture," by Dr. A. Mackenzie. ...	,,	3d.

It is hoped to add to this collection from time to time, and the Hon. Secretary will be glad to have particulars of books, the study of which may be useful to members.

The loan of a book may be had on application to the Hon. Secretary. Postage must be prepaid in all cases, or applications may not be considered.

Readers must keep books clean and not injure or deface them in any way.

The Golf Greenkeepers' Association's Annual Golf Tournament.

The Annual Golf Tournament was held over the Sudbury Golf Club's course, by the kind permission of the Sudbury Golf Club, on August 14th and 15th.

Great interest was shown in the event, nearly 100 competing for the various prizes.

Excellent weather prevailed on this occasion, and the course was in wonderful condition and reflected great credit on the local Greenkeeper, C. A. Tydeman. Not even the critical eyes of the Greenkeepers could find any cause for complaint in this direction.

Thanks to the generosity of the trade, there were ample prizes to be competed for.

The Sudbury Golf Club kindly entertained the competitors to lunch and tea on the two days of the competition, and altogether everyone had a thoroughly enjoyable time.

Leading scores :—

		H'cap.	Total.
‡1.	D. Ness, West Essex	9	146
†2.	J. Spong, Harewood Downs ...	15	148
*3.	P. S. Fergusson, Dulwich and Sydenham	16	149
4.	W. Gibbs, Eastbourne Downs ...	8	149
5.	W. H. Smithers, Shirley Park ...	5	150
6.	G. Gilbert, West Wilts. ...	15	150
7.	E. Bannister, West Surrey ...	14	152
8.	E. G. Burton, Letchworth ...	16	152
9.	S. Morton, Bedford	9	152
10.	R. Audley, Guildford	10	152
11.	H. Lovejoy, Downe	16	153
12.	J. Beasley, Chigwell	8	153
13.	R. Jacobs, Temple	6	153

		H'cap.	Total.
14.	H. Woodcock, Huntingdon ...	8	154
15.	W. Mason, Hendon	11	154
16.	H. Maclean, Sunningdale ...	14	154
17.	J. Flux, Swansea Bay	18	154
18.	T. Bridges, R. Liverpool	12	155
19.	A. E. J. Dash, Oatlands Park ...	8	156
20.	C. S. Paice, Boyce Hill	10	156
21.	C. A. Tydeman, Sudbury	14	157
22.	A. Lacey, Ifield	6	157
23.	J. McDonald, Swinley Forest ...	4	157
24.	A. E. J. Sharp, Grims Dyke ...	15	157
25.	H. Timson, Romiley	9	157
26.	C. Smith, Bramshot	18	157
27.	G. W. Smith, Thorpe Hall ...	6	157
28.	J. L. Ness, Hearsall	9	158
29.	T. Dodd, North Surrey	9	158
30.	C. C. Prickett, Frilford Heath ...	7	159
31.	J. Wallis, Pollards Hill ...	14	159

Special Prizes.

Lowest score (gross) 36 holes: W. H. Smithers, Shirley Park, 82 and 78—160.

Lowest score (gross) 18 holes: H. Alexander, Thorndon Park, 74.

Players over 50 years: A. G. Whitall, Worplesdon, 162; A. Shove, R. Eastbourne, 162.

Artisan Gold Medal: D. Ness, West Essex, 146.

Four ball competition: S. J. Morton, Bedford, and E. G. Burton, Letchworth, 63½.

‡ Winner of "Golf Illustrated" Challenge Cup and Replica, and Messrs. James Carter's Gold Watch and Chain.

† Winner of May's Challenge Cup and Replica and Messrs. James Carter's Silver Watch and Chain.

* Winner of H. Pattisson and Co's. Trophy and Replica.

Immediately after the competition, the prizes were presented by the Captain of the Sudbury Golf Club.

Thanks were accorded to the Sudbury Golf Club for kindly placing their course and Club house at our disposal, and for entertaining the competitors to lunch and tea on the days of the competition. To the prize donors, Major Mullings (the Secretary), Mr. C. A. Tydeman (Greenkeeper), the Steward and his staff, Major Whitley Lavarack, M.C., and fellow members of Handicap Committee, and to Mr. Herbert Robinson, and to all those who had materially assisted in some way or other to help make the meeting so enjoyable.

Winners of Messrs. James Carter and Co's Gold and Silver Watches and Chains since the institution of the Tournament.

Year	Winners of Gold Watches.	Winners of Silver Watches.
1912.	A. Lacey, Burnham Beeches.	
1913.	G. McNeice, Bainstead Downs.	A. Pearce, Coombe Hill.
1919.	W. Hovell, Highgate.	T. Bridges, Addington.
1920.	C. Ranger, Bromley and Beckley.	R. Scott, Chislehurst.
1921.	J. Parsons, Neasden.	E. Penfold.
1922.	T. Mason, Hendon.	W. Soan, Bramshot.
1923.	G. Hewitt, Willingdon.	W. Ball, Woodcote Park.
1924.	A. Shove, R. Eastbourne.	S. Baker, Oxhey.
1925.	W. H. Drewitt, Burhill.	W. Soan, Unattached.
1926.	W. Brook, Woodbridge.	G. Bird, South Herts.
1927.	H. Maclean, Sunningdale.	F. Sumner, Leamington County.
1928.	D. Ness, West Essex.	J. Spong, Harewood Downs.

Mowers and Mowing.

During recent years the main upkeep on golf courses, that is the cutting problems, have been entirely altered. Fairways and rough are in such condition as only existed in the minds of secretaries and greenkeepers in pre-war days, and it is the exception for players to lose a ball, unless very far off in line, or on heather courses similar to Walton Heath.

These results are the outcome of improved cutting machinery, which in their train brought the tractor into use and displaced horses on 75 per cent. of courses.

Dreadful tales were told in the early days of gang mowers, Courses would be ruined by moss and weeds, the bottom of the grass would soon become rotten, and in many instances the adoption of the new way of cutting would be ruin to golf.

Facts, and the use of gang mowers, have proved that all the fears expressed were without foundation; in reality, fairways improved, the more frequent cutting on sandy soils increased the growth of grass, and on clay soils it was found that drier conditions were in evidence during the winter months owing to the non-rolling of the mowers.

Tractors were another evil invention; dire results would follow if used, and there would be no top-dressing available for greens. To-day, no course can be run economically without a tractor for cutting and carting.

The cost of cutting has been enormously reduced during recent years, as the following show:—

42in. mower with horse and man.

Interest on capital, repairs, depreciation, wages and horse keep. Cost, 3s. 4d. per acre.

Quintuple gang mower and tractor.

Interest on capital, repairs, depreciation, wages, and running expenses. Cost, 10¼d. per acre.

The figures may vary slightly under local conditions, but they are relatively a reliable guide to follow.

The cost of the annual repairs varies very greatly, and generally the way the machines are used accounts for the whole of the very great variation in price, as the annual overhaul on "A" course works out at 50 per cent. above "B" course, although both are similar in soil, contour, and general conditions.

One of the most productive causes of heavy repairs is too close cutting; mowers are used with the bottom blades dragging on the ground, with the consequent catching and bending of the cylinder knives, extra fuel is used by the tractor, and undue wear is occasioned all round.

The tractor driver should be warned that his job is cutting grass, and his attention should be on his machine sometimes as well as the tractor; instances of using machines anyhow by drivers have led to dire consequences and heavy repair bills for clubs to meet. Tractor speeds should be not less than six miles per hour when working with heavy-pattern cutters, that is machines bought since early 1927, and not more than five miles per hour for the older, light-pattern outfits. Cutting cylinders should be in very light contact with bottom blades, so that good cylinder speeds can be maintained, and cylinder knife edges should always be wiped with an oily rag when cutting is finished **for the day.**

Mowers for cutting on greens have not made equal radical strides with those mentioned above. Detail improvements have been made by most makers, such as the fitting of ball bearings, steel gears with machined teeth, and gear covers, as well as greater attention to construction and reduction in weight, but hand cutting is still the usual practice on most courses. In a few cases, motor mowers are in use with varying success.

An entirely new machine is wanted, something which will reduce the cost of cutting without lowering the standard of finish which is now universal. If such a machine should "arrive," it must be tried out before being judged. Remember the groundless fears regarding gang mowers, and look for merits, not shortcomings.

The evil of low cutting is even more pronounced on greens than fairways; the subtle difference between clean cutting and close cutting is seldom realised. Too often, greens are "shorn to the bone" with the idea that the cutting should last the maximum length of time before it is again necessary to run the mower over; damage to certain kinds of useful grasses results, and putting becomes more luck than judgment.

Any man who uses a mower cannot know too much about his machine and its adjustments. I believe very strongly that, provided average intelligence is present, each man should be instructed by the greenkeeper in the proper use of his mower, and how to adjust it correctly. I am certain that when he is master of his machine he will use it to better advantage and will take greater care of it. In such circumstances, greenkeepers could issue instructions to their men to put their machines "up a bit" or "set half a mark closer," as conditions required, and know the alterations would be carried out correctly. Mowers, before being put away in their correct positions in the shed, should be brushed to remove grass and mud, and cylinder knives wiped with an oily rag; washing with a hose and water, certainly not; it adds too much to repair bills in the case of ball-bearing mowers, and is not the treatment recommended for any machinery.

REPAIRS.—Annual repairs to machines, if carried out by someone qualified and fitted for the job, are a sound investment, and should be put in hand as soon as the year's cutting is over. Neglect to send mowers in early often means getting them back late, and not in time when wanted for the first cutting. Always have a thorough repair job carried out; it is like an insurance against machine failure during the heavy cutting season, and is worth having done well. "The best is the cheapest" even in repair work. Mowers are always worth care and attention, and will repay many times over for the time spent on cleaning, oiling, and accurate adjusting. Don't always blame the mower, there is generally a man at one end.

HERBERT ROBINSON.

March 14th, 1929.

Draining Sand Bunkers and Reducing Loss of Sand.

On inland courses, where every load of sand has to be bought and carted to the bunkers, we do, or should, realise how important it is, having got the sand there, to keep it there. We cannot control the elements or the present-day niblick, but in my opinion we can do much to reduce the waste of sand, due so often to inefficient draining, overdraining, and the great loss when drains are pierced at various points to get rid of casual water following a heavy fall of rain.

One hears it said very often that sand will not hold up water, but nearly any kind of pit sand, when put at the bottom of a bunker (when the subsoil is clay) will soon consolidate itself to such an extent that it will hold up casual water for a long time. It does, of course, drain away eventually, but far too slowly, and carries with it some of the finer grades of sand, which fill up the drain pipes in a very short time.

Herring-bone Drain in Bunkers.—Every greenkeeper knows the expense of draining bunkers by this process, due to cost of labour, pipes, clinker, etc., and most of us know and have had experience of the amount of sand that finds its way into the pipes, choking them, however carefully laid, causing immense trouble, extra work, and loss of sand. So I think you will agree with me that if we could do without the herring-bone drains in the sand bunkers there would be a great saving in labour and expense.

Now I venture to say that **we can do without them,** or, at any rate, most of them, for I am convinced that, providing the bottom of the bunker is constructed to give a fall from every part of the bunker to the lowest point, it is not necessary to carry more than one drain through the bunker. From a recent experiment in a bunker constructed on these lines, I found it unnecessary to continue with drain through the bunker, stopping at the lowest point. Here a trap was inserted, results being most satisfactory.

I will endeavour to explain the methods I have adopted to get the good results, and which have relieved me of many troubles through waterlogged bunkers and loss of sand.

Let us assume that the bunker has been dug out, the bottom of which has a fall from every part of it (of, say, 1 in 30) to the lowest point, and a drain run through, or up to this lowest point, but well below it. Make at this point a trap, by digging a hole about a foot square to the drain pipe below; cut a small hole in the drain pipe, and stand on its end over the hole a two-inch pipe or pipes according to the depth of the drain below, allowing the top of the pipe to come to within four inches of the surface, filling around this upright pipe with clinker. Make a perforated wood or wire box about a foot square and two inches deep; place good, porous turf upside down in the box, and another turf the right way up on the top; fit this box on top of the upright pipe, then turf the remainder, gradually rising from the trap to the level of the sand. It is important to insert the trap in the turf a foot or two away from, and not in the sand, to get the best results, and be sure the sand is not raked over the trap.

In the case of an already sanded pot bunker, clear the sand, and turf down to where the trap is to be inserted, using this place as a walk-off if possible, so as not to interfere with any special feature of the bunker.

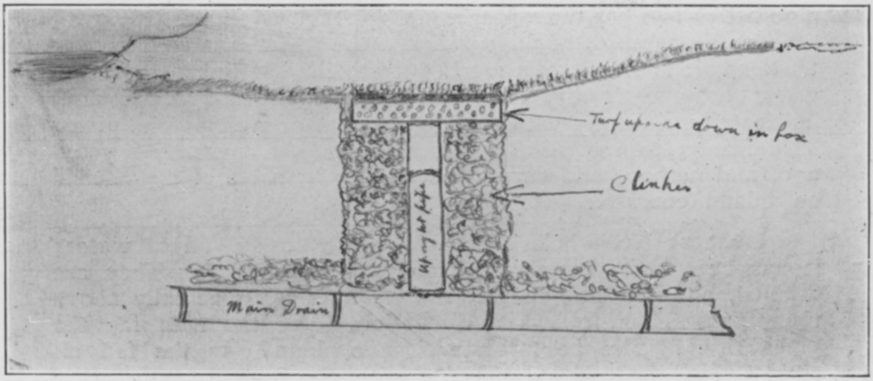
Providing the sand is not raked over the trap, and the pipe below is free, the water will find its way to the trap with little or no sand. Should by chance the water accumulate over the trap, it is a minute's work only to lift the box and let the water away, with very little loss of sand in the process, and, incidentally, do away with that old custom of piercing the pipes. This brings to my mind an incident only too common years ago, and perhaps still carried out to-day by some of my friends on inland courses.

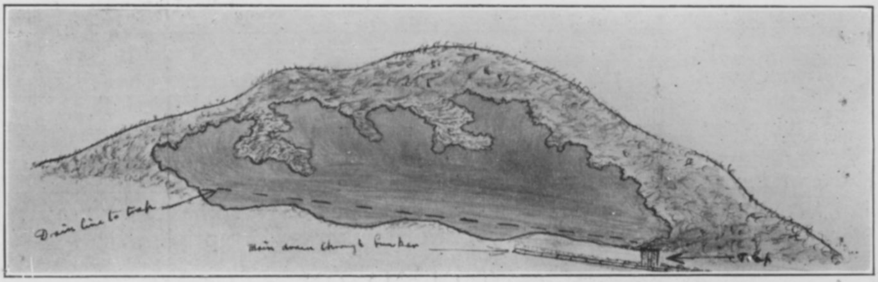
I see at No.— hole the bunkers are nearly full of water; it has been there for days. Cannot understand it. They are drained, and yet, as you see, the water is lying actually above the pipes. Then follows a discussion. Did the man lay the pipes right? Did he put sufficient clinkers? Is the fall all right? Has he puddled the top with clay?—and many other queries as to why the water is so slow in getting away. Something will have to be done. Medal day to-morrow; we must get the water away somehow. The trouble now starts. "Jack, bring the drain finder and pierce a small hole in the pipe." Jack does his duty, carried out under supervision, and the water goes away slowly (taking with it just a little sand). So far, so good. The pipes seem to be doing their work very well. Congratulations on the speedy way the bunkers were emptied (forgetting the sand). More rain comes, more medal days, more water in the bunkers. Jack is sent to repeat as before, but cannot find the same hole, therefore has to make another (still more sand finds its way into the pipes). 1919. 1920. The pipes have been punctured so many times that all that remains are pieces, and Jack cannot find the hole at all; nor can he get the water away (but the sand has gone). Finally the bunker has to be redrained and sanded, for the pipes are all choked up with it. Diagram of bunker and trap below.

TOM MASON,

Greenkeeper,

Hendon Golf Club.


Clinker
Main Drain


Drain line to trap
Main drain through bunker