

Controlling Weeds in Putting Greens

By John Monteith, Jr.

The control of weeds continues to be the most perplexing of putting-green problems on many golf courses in spite of the great variety of methods that have been advocated in recent years as being sure remedies for weeds. In the early days of golf a large assortment of weeds around a hole was probably never mentioned as justification for missed putts. However, as the surfaces of putting greens gradually have been improved through the course of years it is natural that any unevenness produced by any cause whatever should be more aggravating to the player. As refinements in putting greens have been made and the costs of maintenance have increased there has naturally followed a demand for some means of preventing the encroachment of undesirable plants. An occasional weed in many cases is of little immediate consequence in a putting green. However, a few may be extremely serious as initial sources of further contamination which may ultimately ruin the surface of a good putting green. Many plants which at times are not objectionable on putting greens and on certain occasions are actually extremely desirable, may be regarded as pests for the reason that they become dormant or easily injured in certain seasons and leave large patches of discolored or dead vegetation in otherwise perfect turf. Annual bluegrass and pearlwort are examples of this type of turf plant.

When weeds become well established on putting greens their control usually involves a large expenditure of funds and effort. On many golf courses the removal of large quantities of weeds from putting greens by the hand-picking method is an annual procedure, which is no insignificant item in the club's budget. The patchy appearance of the turf and the uneven playing surface usually resulting from the depredations of a gang of weed pickers greatly interfere with the playing conditions for altogether too long an interval. Important though the hand-weeding method may be in the general program of weed eradication, a good share of this work might be avoided if clubs would realize that the old adage "an ounce of prevention is worth a pound of cure" is as applicable in fighting weeds as in combatting many other evils.

TWO PHASES IN WEED CONTROL

There are two phases of successful and economical weed control. The weeds which are already in turf must be removed or destroyed by some method which will prevent their spread and perpetuation by seeding. In addition to destroying the weeds already in turf some precautions must be taken to guard in every possible way against infestation from all probable sources. On many golf courses large annual expenditures are made removing weeds from greens while at the same time large quantities of weed seeds are actually being sown on the turf through the medium of top-dressing. On other courses large quantities of weed seed are grown each year on areas adjacent to a green from which the seed may be readily carried onto the green by wind or water. Such neglect makes it necessary to continue the annual expenditure for hand weeding.

WHAT IS A WEED?

A weed is a plant growing in a location where its presence is not desired. There are no distinct species of plants universally designated as weeds, since a plant which is a weed in one place may be a very desirable and much sought-for plant under other circumstances. Clover, for example, on a putting green is a weed, whereas in pastures it is an extremely valuable plant which farmers try to encourage in every possible way. Likewise Bermuda grass, which is our most valued grass for southern golf courses, is regarded as one of the worst weed pests known to farmers in many sections of the South. Even on golf courses Bermuda grass may be regarded as a weed. In the extreme northern part of its range, for example, it may crowd out more permanent grasses during a favorable season and then may be completely destroyed by a cold winter, leaving large bare patches where all other grasses have been smothered out and miscellaneous weeds may easily become established.

KINDS OF WEEDS

Weeds are commonly grouped for convenience in several different classifications in addition to their botanical classifications. One classification divides them into annuals, biennials, and perennials, according to whether they live respectively for one, two, or several years. Annual weeds, of which crab grass is a well-known example, depend for their perpetuation on the production of a crop of seed each season. If annual weeds are not permitted to go to seed on a putting green and if no new seed is allowed to get on the green there will be no weeds the next season. In the case of some perennial weeds the problem of their eradication is difficult due to their spreading habits and their ability to remain alive in a green year after year even though they are so insignificant as to be scarcely noticed in the grass until later neglect permits them to again dominate the situation. White clover is an example of a perennial putting-green weed. Weeds are also frequently classified according to root growth; that is, whether they have deep taproots, such as dandelions, or shallow, fibrous roots, such as are found in many of the grass weeds. Those with deep taproots are more difficult to eradicate because, in weeding, a part of the root may be left in the ground and be able to send up a new plant from the base of the root. They are also classified according to the period of development; that is, winter and spring weeds or summer weeds. Crab grass is an example of seasonal weeds. In still another common classification some are grouped as creeping weeds, as contrasted with those that grow upright. Creeping weeds, such as chickweed, are most troublesome in closely clipped turf, whereas the upright-growing plants, such as pokeweed, are soon destroyed by close mowing. Every classification of growing things is merely for convenience and is subject to the criticism that it does not hold true for all cases because of the large number of instances which overlap. This overlapping is especially likely to occur where artificial conditions play a part in influencing the natural development of plants. Annual bluegrass is an example; for this grass which, under average natural conditions is distinctly an annual, under artificial conditions on golf courses may survive more than one year.

There is wide variation in the habits of growth of different weeds. This variation in growth characteristics is important in any discus-

sion of weed control since the habits of the plant often have an important bearing on its response to certain treatments. Many of the weeds that are common agricultural pests have an upright growth which enables them to compete most successfully with many agricultural crops. However, this very habit is a distinct disadvantage to these weeds in putting greens for close mowing will soon eliminate them. Many weeds of this type spring up in newly planted greens and often give those in charge of the course much concern, whereas as a matter of fact they are of little importance because they will not survive many weeks after the program of close mowing is started. Some putting green weeds, such as pearlwort, are in the habit of growing in wet soil and are most likely to be troublesome in poorly drained greens where the soil is soggy. Pearlwort, like other weeds that have special preference for certain soil conditions, is, however, able to grow under a wide variety of conditions and may occasionally prove troublesome where the best of drainage is provided. Some weeds prefer rich soils and others prefer soils that are impoverished. White clover is an example of putting green weeds that are more likely to become troublesome on soil that is deficient in nitrogen. Although plants thrive best under certain fairly definite conditions of soil and climate, they all have a relatively wide range of adaptability and many grow successfully under conditions that are considered to be far from the optimum. The occasional exceptions to the usual response are puzzling, but they by no means change the general rule and need not interfere with a consideration of general principles.

In many instances there are decided differences between the conditions that are most favorable for certain weeds and those that are best for desirable turf grasses. In such cases it is often possible to control the weeds effectively by modifying the surroundings. The weeds whose habits of growth most nearly coincide with those of the grass being raised on a putting green are the weeds which are generally most persistent and troublesome. In putting greens, more than anywhere else on a course, artificial means are often available to make the soil conditions as nearly as possible the most suitable for the desired turf grasses.

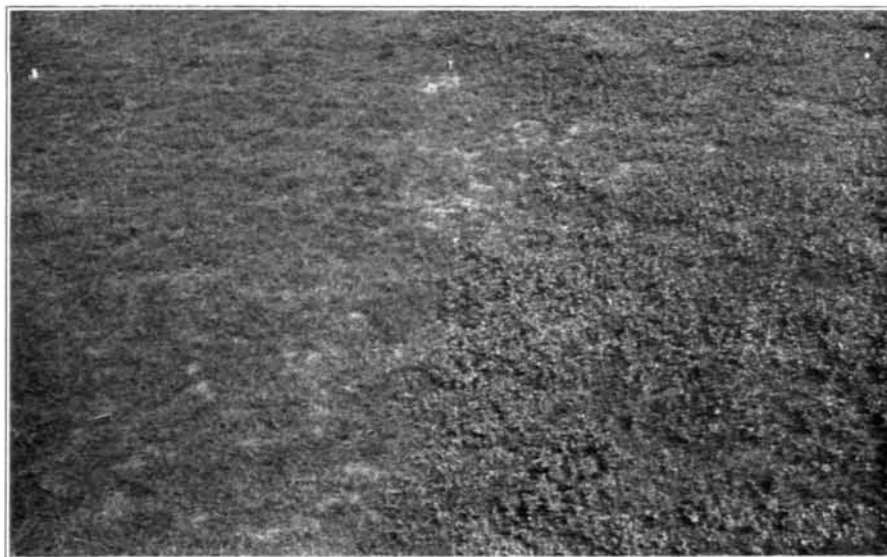
SOURCE OF WEEDS IN PUTTING GREENS

New weed plants originate in two ways; from seed or from buds taken from rootstocks, stolons, or stems of parent plants. Examples of weeds growing from seed are crab grass and plantain. Examples of those frequently originating from shoots as well as seed are white clover and chickweed. Any successful program of weed control must take into consideration the probable sources of the weeds, for their mere removal is only a temporary measure if some protection is not provided against reinfestation. Weed seeds may be carried onto greens mixed with top soil or manures. They may be unintentionally sown as impurities in grass seed. They may be washed onto the turf by surface water from adjoining weed-infested areas. They may be carried on the shoes of players and workmen and on mowers or other equipment used on the turf. They may be blown onto the greens by winds, and they may be spread by numerous other natural or artificial means. Stems or roots which may give rise to new weed plants may be carried onto greens in much the same manner as are the seeds.

The only satisfactory way that has so far been discovered to fight weeds on putting greens is to combine preventive with curative measures. In recent years there have been numerous attempts to control weeds by some simple method which would be effective in all cases. Thus far all these efforts have been futile for the reason that many factors must be considered in weed control, and it is probable that any single method when used alone will continue to be only partially successful. An example of this is hand picking which, when properly done, is naturally an effective control method. However, if the weeding is delayed until the weeds have produced and distributed a large quantity of seed on the green it follows that the remedy will only be a temporary one, for a new crop of weeds will come up from the seed left on the putting green. Likewise if top-dressing or fertilizers containing weed seeds are used on the most carefully weeded green a new infestation is assured.

PRODUCING A WEEDLESS TOP SOIL

The first important step in controlling weeds is to start with a soil that is as free as possible from weed seeds. In making a new green it is important that the young grass have a minimum of competition



Of first importance in the control of weeds is to start with a weedless top soil. The top soil used on the left half of this section of a fairway was relatively free from weed seeds while the soil used on the right half was heavily infested. The same grass seed was planted on both areas

from weeds. If the weed seeds in a soil are of plants that spread very rapidly it may be that the putting green will be permanently damaged before the grass can become established. Before planting a green the soil may be largely rid of weed seed by cultivation. As soon as a large number of weeds appear, the ground should be stirred with a disc or harrow to kill the plants and bring new weed seeds to the surface where they can germinate and later be killed by further cultivation. A frequent repetition of this process will destroy a great many weeds before the green is sown and will give the grass the advantage of a better start. This method of cultivating the top soil in

preparation for the planting of new greens is seldom practiced because of the usual rush in getting the job finished for an anxious membership. To most new clubs the speed of construction of the golf course is invariably a more important consideration than is weed control. The weed problem is usually left for solution at some later date after the course has been open to play. In the accompanying illustration is shown the difference in weed growth in seedling grass growing on two different top soils, one relatively free from weed seeds and the other badly infested with seeds of several species of weeds.

PROTECTION AGAINST WIND- AND WATER-BORNE WEEDS

Seeds and shoots of weeds are frequently carried onto a green by wind and surface water. Some weed seeds, such as those of dandelion, are provided with attachments which make it possible for them to be carried long distances by wind. Seed from such weeds can be blown onto the greens from the rough or from land beyond the limits of the club property. Against this source of infestation there is little that can be done in the majority of cases, but in some instances chemicals and timely mowing have been effective in reducing the production of seed. Traps and grassy mounds wherever possible on the windward side of putting greens will catch a large percentage of the weed seeds that are blown from the rough or areas out of bounds. Higher ground in the vicinity of the putting green may be covered with weeds that are producing great quantities of seed. Unless some provision is made for the prevention of water carrying the seed from such areas onto the putting green there is likely to be a heavy planting of weed seed over any portion of the green where surface water runs during heavy rains. Properly placed grassy hollows just beyond the edge of a putting green can turn off surface wash and thereby prevent the distribution of water-borne weed seeds, in addition to serving as a protection to greens from other damage caused by excess water.

PROCURING WEED-FREE SEED AND STOLONS

If the top soil of a new putting green is relatively free from weed seed and proper precautions in construction are taken to insure against weed contamination, it is then important to plant the green with seed or stolons that are relatively free from dangerous weed seeds. A great deal of low-grade putting green grass seed contains large quantities of weed seed, therefore it is poor economy to plant such seed even though it may be bought at a low price. Chickweed is an example of troublesome putting green weeds the seed of which is frequently found as an impurity in seed of putting green grasses. Stolons frequently come from nurseries where there is a heavy infestation of weeds and the soil adhering to the stolons is apt to carry a great many weed seeds. In planting stolons it is also important to avoid weed-infested top soil for covering them.

INCREASING WEED RESISTANCE OF TURF

In selecting the type of grass to plant on putting greens it is well to consider its ability to resist the encroachment of weeds. Some grasses which are capable of producing excellent putting green turf, soon after they are planted are usually not able to withstand putting green conditions and after the first or second seasons begin to

weaken. As soon as a grass is injured or weak it is unable to crowd out some of the common weeds that are soon overcome by a more vigorous grass. Fescues on putting greens under the big majority of conditions in this country offer little competition to weeds on greens. Some of the strains of creeping and velvet bents, on the other hand, are much more capable of successfully competing with ordinary weeds. The Columbia and Virginia strains of creeping bent, however, are examples of bents planted with the stolon method which are readily invaded by weeds, whereas the Metropolitan strain is one of the most resistant to common weeds. The more aggressive and sturdy of the creeping and velvet bents in addition to preventing many weeds from becoming established in their dense turf are quickly able to cover any bare patches left by weeding or other injuries. This prompt covering with new turf gives weeds little opportunity to become well established before they must encounter the competition of vigorous grass. Such grasses as fescues which do not have an aggressive creeping habit are unable to fill in the gaps left by weeding, diseases, or other injury, and their use on putting greens therefore invites trouble from weeds.

WEEDING GREENS BY HAND

An inspection for weeds should be made as soon as the young grass is well established on a new putting green. If badly infested soil or seed has been used in establishing the green a large quantity of weeds will soon appear. If most of these weeds are of the upright-growing type they may be left for the mowers to destroy. However if there is a large infestation of the weeds that are particularly troublesome on putting greens it is advisable to start hand weeding as soon as it is safe to put weeders to work on the soft soil. Hand weeding can be done much more rapidly when the weeds are small than when they are well rooted and firmly established in the turf, also the longer these weeds are left in the turf the more damage they will do in smothering out the seedling grass.

Frequently large gangs of weed pickers are used on putting greens to pick out by hand hundreds of thousands of weeds. This hand-picking method is not only costly, but unless skillfully done it leaves the green very badly scarred with pits from which the weeds have been removed. Nevertheless the hand-weeding method is the most certain to accomplish complete mastery of the weed problem. Frequently hand weeding is only a minor chore which is taken care of day by day by the men who operate the mowers. If proper precautions are taken against re-infestation and proper fertilizing and other practices are in use it is a simple task for those who are caring for the turf to remove the occasional weeds that appear from time to time just as soon as they are noticed. Such a procedure is the most desirable one, for in addition to preventing any production of seed on the greens it keeps the weeds so constantly under control that the putting surface is never marred by coarse plants nor by numerous scars left by wholesale removal of weeds. On the majority of courses weeds become too numerous on putting greens for the regular staff of workers to compete with. It then becomes necessary to employ extra help or to organize weed-picking gangs from other helpers about the course. In hand weeding it is important that the workers be made to realize the necessity of removing the crown and main roots of plants rather than be satisfied with merely pulling off the top growth.

It is desirable to leave weeds until they have developed sufficient top growth to be easily handled. On the other hand they must not be left too long lest they smother out the grass around them and leave large bare patches when they are finally removed. Small weeds can be pulled out more easily than large ones and require less digging. In any case weeds should be removed before they produce seed. Frequently one finds gangs of weed pickers at work removing such weeds as crab grass long after the weeds have started to seed. Such plants easily shed their seed and late weeding simply removes the old plants but leaves on the greens perhaps hundreds or thousands of seed to provide employment for similar gangs of weeders at some future date. It is also well to bear in mind that in the case of weeds such as dandelions which have deep taproots it is essential that most of the roots be removed, for leaving in the ground main taproots with simply small pieces of tops removed is as bad as leaving viable seed in the turf, because such roots may send up new plants to replace the old ones. A common practice is to kill this type of weed by pricking the crown with some sharp pointed instrument and injecting a chemical such as sulphuric acid or carbon bisulphide. Another method is to sprinkle the crowns of these plants with liberal quantities of sulphate of ammonia or common table salt. This method of using chemicals is a tedious one and has the disadvantages of leaving scars where the chemicals have killed surrounding grass, but it has the advantage of killing the roots and preventing a new growth from below. To thoroughly weed a putting green it is best to mark it off in small sections with twine and to proceed systematically over the entire area. After any extensive weeding operation it is necessary to restore a true putting surface by applying a layer of top-dressing to the pitted greens. If the top-dressing used for this purpose contains hundreds of thousands of weed seeds the weeding process will soon have to be repeated, because weed seeds find ideal conditions for germination in a layer of top-dressing kept constantly moist by sprinklers.

TOP-DRESSING WITH WEED-FREE COMPOST

Probably one of the most common origins of weeds in putting greens is improperly prepared compost. Good compost is one of the greenkeeper's most valuable assets. However, unless it is properly prepared it may be one of his greatest annoyances. Compost can be prepared in various ways, as will be more fully explained in the next number of the Bulletin. It is interesting to observe compost piles and soil beds on various golf courses and note the attention or lack of attention given to the weed problem in the use of top-dressing material. Many compost piles and soil beds are simply propagating beds for weeds, where the large crops of seeds produced are simply worked through the compost and spread on putting greens where conditions are ideal for germination and development. Other greenkeepers keep their soil beds or compost piles entirely free from weeds and make provision to protect them from weed seeds produced in adjoining neglected areas. Annual weeds are more likely to be abundant around compost piles or soil beds due to the fact that they are able to produce a crop of seeds during short periods of neglect. Seeds of annual weeds are therefore likely to be most abundant in the top-dressing used on greens.

During the season of 1929 some tests were made to determine how much of a factor top-dressing actually was in the distribution of

weeds on putting greens of representative golf courses. Samples of top-dressing material, already prepared for use, were obtained from several courses in the vicinity of Washington. Equal volumes of these samples were spread in thin layers over sterilized soil in wooden flats, which were kept constantly moist to encourage germination of any weed seeds they contained. Similar samples of the top soil used on the Arlington turf garden, and of compost which had been sterilized with steam were tested. Weeds soon appeared in all of the flats except the one containing sterilized soil. In some cases only a few appeared, but other flats were soon covered with a dense growth of weeds. A photograph of 9 of these flats is here shown. The difference in the amount of growth with different composts is quite evident. This illustration shows clearly why it is that some green-



Nine samples of compost collected from golf courses showed remarkable differences in weed infestation when placed in flats and subjected to growing conditions and offer an explanation of the greater abundance of weeds in the greens of some courses as compared with others. Some of the flats are almost weed free. Tests of this kind have demonstrated that it is not unusual to plant 70,000 weed seeds on a putting green in a single top-dressing

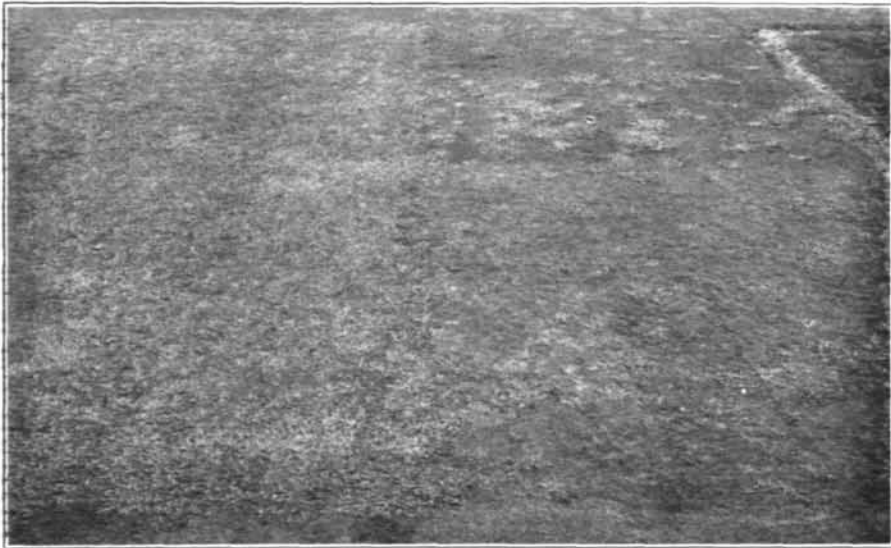
keepers have little trouble with weeds whereas others regard putting green weeds as their greatest problem. These tests showed that in the compost used on some courses hundreds of viable crab grass seeds were present in a shovelful of compost. The greens on the course from which this compost was obtained were constantly being weeded, after each weeding the greens were top-dressed, and by means of this top-dressing with compost a new crop of crab grass was planted. The new crab grass seedlings germinating in the holes left by the hand weeders found little competition from the bent grasses. By the time the bent had recovered from the weeding process the crab grass seedlings were well established and able to withstand any competition. A sample from one of the courses produced numerous chickweed plants and, as might be expected, chickweed was the most troublesome weed on the greens of this golf club. Numerous plants of annual bluegrass appeared in some of the flats. Four of the samples contained scarcely any seed of weeds that are objectionable on putting greens. This relative freedom from weeds in

these few samples showed clearly the possibilities for controlling weeds in compost by properly preparing it.

The danger of this method of distributing weed seeds is perhaps more clearly brought out by figures. From the above tests and other similar trials it was found by actual count that it is not unusual for a single quart of compost being used on a putting green to produce one hundred or more vigorous weed plants under favorable conditions. Many may produce several hundreds. If one quart of compost will produce 100 weeds, one cubic yard of that material will produce about 70,000 plants.

STERILIZATION OF SOIL AND COMPOST

One of the common methods of destroying weed seeds in soils is that of partial sterilization by either the steaming or the baking process. The danger from weed seeds in soil for use in tobacco seed



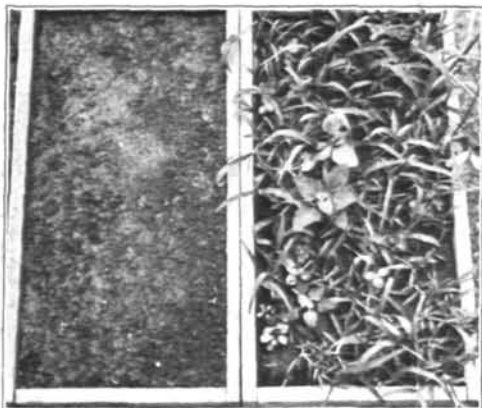
With the use of sterilized top-dressing material a marked effect in reducing weed growth is noticed. The weedy turf at the left was grown on a top layer of weed-infested compost. The same compost was used on the adjoining section to the right except that it had been steamed before it was used

beds and for certain horticultural crops has led to a wide-spread use of the sterilizing method for weed control. In a few cases this same treatment has been used on golf courses. The method is somewhat expensive, but it is entirely practicable for certain agricultural crops and also for soils for putting greens. If proper precautions are taken in the preparation of compost piles or soil beds under ordinary conditions there will not be enough weed seeds in the soil to justify the expense of sterilization. However there are some cases where certain local conditions make it almost impossible to protect soil from weeds. Under these conditions it is economical to destroy with heat the weed seeds that have accumulated in the soil. Such cases have been referred to in previous numbers of the Bulletin. The saving in the cost of hand weeding as well as the avoidance of scars resulting from removing weeds by hand are sufficient to justify the extra expense of sterilization in these instances. Naturally the decision as to the prac-

ticability of this method will be determined by the kind and quantity of the weed seeds contained in the compost and also the feasibility of other weed control treatments. The elimination of the source of infestation frequently costs far less than the destruction of seed in the soil, but on the other hand some method of seed destruction is often far less expensive than repeated weeding.

At the Arlington turf garden during the summer of 1928 a demonstration was made of the effect of sterilizing top soil on the prevalence of weed seed. The top 3 inches of soil was removed from 4 plots. This top layer was replaced with a weed-infested top soil. Two of the plots received soil which had not been sterilized and the other plots received the same soil after it had been sterilized with steam. One of the two plots containing the sterilized soil and one of the two containing the unsterilized soil were then seeded with mixed bent seed and the other two plots were planted with stolons of Washington creeping

bent. Throughout the summer these 4 plots gave an effective demonstration of the advisability of providing weed-free top soil. The 2 plots receiving the unsterilized top soil were literally covered with weeds, particularly crab grass. The two plots on the sterilized soil had only an occasional weed in them and the grass grew just as rapidly in the sterilized soil as in the unsterilized; moreover, for a time it grew more rapidly. The illustration shows the appearance of 2 of these plots in late summer. Some sterilized soil was placed in a small flat beside one containing some of the same soil which had not been sterilized. These flats were



Sterilizing compost is an effective means of destroying weed seeds. The flat on the left contains compost that had been sterilized with steam while the flat on the right contains a portion of the same sample of compost not sterilized. Both flats were watered and kept side by side under identical conditions from the time they were filled with the compost. No weeds germinated in the sterilized compost while the unsterilized developed an abundant growth.

watered regularly to encourage germination and growth of any viable seeds contained in the soil. The effect of sterilization in destroying the weed seed contained in the soil is well shown in the illustration of these two flats. This method of putting soil in flats and keeping it under favorable conditions for weed growth offers an excellent means for the greenkeeper's checking up on the amount of weed seeds he is sowing on his putting greens through the medium of top-dressing. It is advisable to keep testing compost from time to time by this means. It is also advisable to keep on the lookout for a growth of weeds in any piles of surplus compost that have been left over when preparing the top-dressing for putting greens. If these left-over piles are out of doors where they are exposed to rain and favorable conditions for germination of seed it will be possible to get an approximate idea of the amount of weed seeds that is being distributed on the putting greens.

Soil may be sterilized by baking it or by cooking it with steam.

There are two common methods for steaming soil. With one method steam is forced through perforated pipes beneath a pile of soil and as the steam works up through the soil it raises the temperature sufficiently to cook and kill all seed. This method involves moving and handling of soil. Another method is to cover an area of soil with a weighted air-tight pan. Steam is then forced into this pan under pressure. The heat works down from above and cooks the seed in the top few inches of soil. This method usually requires much more time for thorough sterilization than does the former; however, the steam-pan method does not require any moving of the soil and is therefore economical where the soil is not being moved, as is usually the case in tobacco seed beds, or in putting greens that are being sterilized before planting. Where soil is to be used for compost and is being handled anyway it is usually more economical to use the other method of steaming. There is almost no end to variations in the equipment which has been devised for steaming soil. These variations are made to conform to certain local conditions and to provide for more economical handling. A great many of these variations are ingenious and effective and all are permissible provided they accomplish the purpose of cooking the big majority of the weed seeds contained in the soil. Methods for sterilizing compost on golf courses have been given in more or less detail in previous issues of the Bulletin. Those who are interested in this work may refer to the following articles in the Bulletin: page 233, October, 1925; page 5, January, 1926; page 202, September, 1926; page 119, June, 1921.

INFLUENCE OF FERTILIZERS ON WEEDS

In recent years a great deal of attention has been given to the control of turf weeds by using certain fertilizers. The old method of fertilizing turf was to top-dress with a layer of some kind of animal manure. This method has rapidly lost favor for putting green purposes during the past decade partly due to the objections from the standpoints of appearance and playing and also because it has been clearly demonstrated that weeds are generally greatly encouraged by top-dressings of manures. The use of manures on putting greens is now confined chiefly to their use as an ingredient of compost or in some special form of fertilizer in which weed seeds have been destroyed during the process of manufacture. The modern tendency is to use on putting greens only fertilizers which contain no weed seeds and which in addition tend to discourage weeds. Sulphate of ammonia is the most outstanding example of fertilizer used because of its value as a grass food and also because it tends to reduce the abundance of weeds. This fertilizer has been repeatedly shown to be capable of preventing the germination of many troublesome turf weeds. This influence of sulphate of ammonia on certain weeds has been attributed to various causes, especially to the increased acid reaction of soils to which it had been frequently applied. However, it has long been known that the same influence on weeds might be exerted on certain soils without making them acid. A satisfactory explanation of this influence has not yet been given. One of the indirect effects of sulphate of ammonia on weeds, which is often of more practical importance than its direct effect, is caused by its stimulation of a vigorous growth of grass. This stimulation of the grass results in a crowding out of the undesirable plants, thereby controlling weeds

simply by natural competition. Other fertilizers containing nitrogen in a form that is readily available to grass exert a similar influence on the abundance of weeds. A directly opposite influence on competition may be exerted by other chemicals. In the case of lime, for instance, when used without nitrogenous fertilizers, the advantage is given distinctly to clover and this weed is enabled to compete more successfully with grass plants. Nitrate of soda is an example of a nitrogenous fertilizer which in many soils will throw the balance of competition in favor of certain weeds. None of the fertilizers will completely control weeds. Their proper use can only influence to a certain degree the severity or insignificance of the weed problem. Many individuals completely ignore this influence of fertilizers on weeds because they have failed to obtain miraculous results when they have tried them. If however no provision is made against infestation by seeds from sources indicated above it can not be expected that any fertilizer should perform such miracles.

Some fertilizers, as for instance sulphate of ammonia, when applied in excess, are likely to injure some weeds more severely than they injure grass. This selective effect may be used to advantage in controlling some weeds, for if the proper amount of fertilizer is used it is possible to kill the weeds but at the same time leave enough live grass to recover and with the stimulus of the fertilizer to cover quickly the injured area with a vigorous new growth of grass. Clover, chickweed, and other weeds forming dense mats are frequently checked in putting greens by sprinkling the foliage with sulphate of ammonia powder early in the morning when there is a heavy dew. Later in the morning after the weeds are burned the patches are watered. For this work, an ordinary salt shaker is often used for applying the sulphate of ammonia. The best rate of application for local conditions can soon be determined by trials on a few small areas. To be successful, this method must be used with caution and must be repeated as needed.

To determine the effect of various fertilizers, compost, and manure on the control of crab grass and goose grass, and the comparative resistance of the Metropolitan and Washington strains of creeping bent to infestation by these two weeds, observations were made at Arlington turf garden on 22 plots of these grasses over the 4-year period 1924 to 1928. Some results are shown in the following table. The plots under observation were 64 square feet in size. The weeds were taken out and counted August 22, 1928. Each plot had received the treatments indicated in the table continuously for the 4 years and had been given no other fertilizers or top-dressings since it was planted. The check plot had been given neither fertilizer nor top-dressing. Some of the plots were at the ends of the two series and were adjoining turf badly contaminated with weeds, and the proximity to this constant source of weed seed probably accounted for the greater abundance of weeds occurring in these plots; they are marked with an asterisk in the table. Other plots which were adjoining weed plots in the same series probably had a somewhat misleading number of weeds. However, even though the table should not be used in drawing too fine deductions between treatments, it is interesting to note the striking increase in the number of weeds counted in the plots receiving compost and manure as compared with nearby plots. In each series the three plots receiving compost and manure contained

more weeds than the other 19 plots combined. It is also interesting to note how the addition of sulphate of ammonia to the compost reduced the number of weeds as compared with the plots that had received the same amount of compost without any addition of fertilizer. It is apparent that the compost used in these tests was one improperly prepared, but in this respect it was similar to that used on too many golf courses.

The table also indicates the difference in weed resistance shown by different grasses. It must be remembered that the table shows only the crab grass and goose grass and does not include the numerous other weeds that were present. The calcium carbonate plots, for instance, according to the table had relatively few of these weeds, but clover had completely invaded them.

The figures in the following table show the number of plants of crab grass and goose grass removed from twenty-two 64-square-foot plots each of the Metropolitan and Washington strains of creeping bent, twenty-one of which had been subjected to different fertilizer treatments over a 4-year period

<i>Plot treatment</i>	<i>Metropolitan creeping bent</i>	<i>Washington creeping bent</i>
Sulphate of ammonia.....	*140	43
Nitrate of soda.....	*172	60
Urea.....	55	*83
Ammophos.....	40	*72
Calcium carbonate.....	35	58
Magnesium carbonate.....	30	72
Sodium carbonate.....	27	69
Potassium carbonate.....	24	193
Calcium carbonate and urea.....	22	..
Potassium carbonate and urea.....	..	48
Magnesium carbonate and urea.....	15	28
Ammophos, urea, potassium nitrate.....	6	24
Ammophos and urea.....	20	7
Potassium nitrate and urea.....	13	25
Potassium phosphate.....	25	67
Compost.....	492	877
Compost and sulphate of ammonia.....	254	301
<i>Check plot (no treatment)</i>	50	185
Ammonium nitrate.....	13	42
Bone meal.....	25	149
Manure.....	131	516
Cottonseed meal.....	12	49
Soybean meal.....	3	19
Total	1,604	2,987

CONTROL OF WEEDS BY USE OF CHEMICALS

Certain chemicals which are not regarded as fertilizers are frequently used for weed control. Sodium chlorate, calcium chlorate, ordinary table salt, iron sulphate, and many others are frequently used on golf courses, but their use is ordinarily confined to the fairway and the rough. As a rule, on putting greens they are too likely to cause damage, and the risk of using them there is too great for general adoption. All of these chemicals however have possibilities provided they are handled with extreme care and tested thoroughly on small areas of a putting green before they are widely used. Arsenate of lead, corrosive sublimate, calomel, and other insecticides and fungicides have repeatedly given results which show that they are capable of controlling weeds under certain conditions. However most of the results obtained indicate that the weed control in such cases is secondary. When insects or diseases injure turf and leave scars, any

weed seeds present can germinate and develop in them without competition. If turf is permitted to become badly scarred by the ravages of insects or diseases it is likely to become very weedy; therefore any control chemical which prevents injury to turf and thereby encourages a constant, vigorous growth of grass which serves to maintain an aggressive competition against weeds will in effect act to control weeds. Such chemicals however can not be generally advocated simply as means for controlling weeds, for the reason that they do not work in turf where the factors of disease or insect damage are not important. In the case of arsenate of lead, there have been indications that some weeds of the thickly-matted type, such as chickweed, can be controlled even in the absence of insect injury. This type of weed however is ordinarily easily controlled by cheaper chemicals than arsenate of lead and therefore it is not advisable to go to the expense of using arsenate of lead chiefly to control weeds on putting greens where grub injury is not expected to become a serious factor. Sulphates of ammonia or iron are examples of cheaper chemicals that will give similar control of the type of weeds that may be checked by arsenate of lead.

SOIL ACIDITY AND WEEDS

For a great many years acid soils have been regarded as most desirable for bent grasses and likely to discourage weed growth. To a certain degree this is true, but the enthusiasm of some of the earlier advocates of this method carried it beyond reasonable limits and resulted in making the soil on many putting greens entirely too acid. Sulphate of ammonia, powdered sulphur, aluminum sulphate, iron sulphate, or other chemicals are available to make soils more acid. Undoubtedly much of the beneficial result in reducing the weed infestation in putting greens which was attributed to the accumulating acid reaction of sulphate of ammonia was in reality due chiefly to the large supply of quickly available nitrogen and the resulting increased competition that the weeds encountered. Many golf courses which for several years applied sulphate of ammonia regularly with the idea of controlling weeds by making the soil acid accomplished the desired results but later found that although they had controlled the weeds they had actually not increased the acidity of the soil due to the fact that lime had been unknowingly applied frequently in the form of lime in sand or through the regular water supply. This failure of acidity of soil to accomplish all the results claimed for it has been apparent for a great many years; nevertheless many of those who are connected with golf clubs are still under the impression that soil acidity is the most important objective in the use of sulphate of ammonia. The danger in excessive soil acidity was pointed out in the Bulletin for May, 1929. The most desirable degree of acidity for bent greens has not been definitely determined and therefore no positive recommendations on this subject can be regarded as reliable. For weed control it is best not to pay too much attention to soil acidity but rather to give attention to the vigor of grass growth regardless of acidity. An application of lime to an acid soil, even though it makes the soil less acid, does not noticeably stimulate weed growth. However lime used in excess without regard to other fertilizers, and particularly those containing nitrogen, will invariably increase the weed growth. From the weed control standpoint therefore soil acidity does not offer any simple solution of the problem of better putting greens.