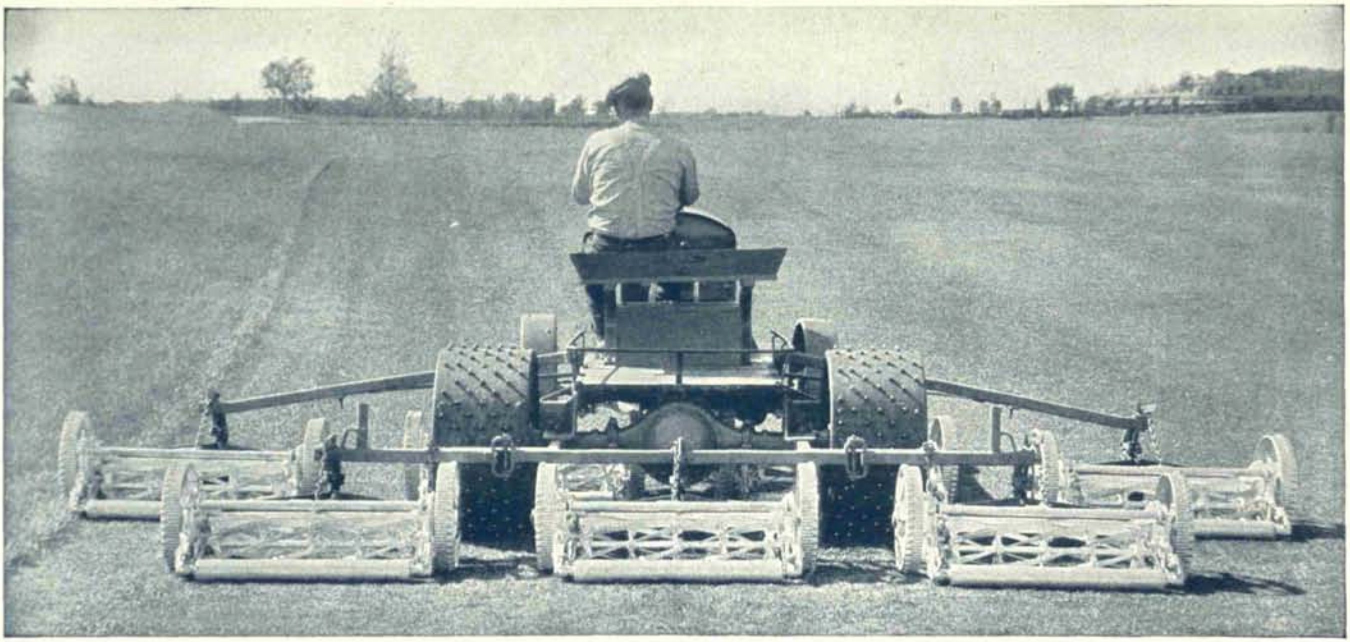
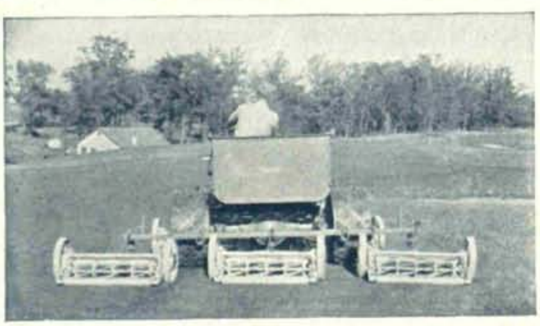


Faster—Better—Cheaper

Note the arrangement of the two front mowers, which cut the grass before it is matted down by the drive wheels.

For transporting, the mowers are swung around behind, and the total width is less than that of a three-unit outfit.



New Master five-unit outfit. Two extra mowers can be added instantly, converting it into a seven.

Last year's mowing machines are as dead as last year's dandelions as far as present conditions are concerned.

The Toro Master Seven is more flexible, faster and saves 50% in operator's time, with constant savings in operating and upkeep costs. Cuts a 16-foot swath, mowing a standard 18-hole golf course in approximately eight hours. It will pull seven mowers in high gear over 20% grades and five mowers over 25% grades. It does better work because the two front mowers cut the grass before it is matted down by the drive wheels, thus eliminating all streaks after cutting. The two outside mowers are opposite the driver so he can easily watch his cutting swath.

A wheel base of only 103 inches from the front of the tractor to the rear mower provides a closely-coupled mowing outfit with a maximum degree of flexibility. Sturdy electrically-welded frame . . . no twisting or buckling, even when used on roughest ground.

The Toro Master Seven can be used for many jobs besides mowing. The mowers and frame can be disconnected in five minute's time and the tractor used for general utility purposes.

If you are faced with demands for lower maintenance costs, it will pay you to see your nearest Toro distributor, or write for full details.

The Toro Manufacturing Company

3042-3160 Snelling Avenue **Minneapolis, Minnesota**

APRIL, 1932
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The NATIONAL GREENKEEPER

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The Vitality of Shade Trees in Relation to Root Environment

By HOMER L. JACOBS, *Arboriculturist,*
Davey Tree Expert Company, Kent, Ohio

Read at the 6th Annual Educational Conference of the National Association of Greenkeepers of America, held at New York City, January 19-22.

GREENKEEPERS or golf course superintendents have much the same problems in tree care as do large estate or park superintendents and street tree commissioners. That is, they are interested both in planting new trees from time to time and in keeping those already established in good condition. This is a large subject and one that can hardly be outlined in a short paper. For this reason, I shall confine my discussion to some of the reactions of roots to their environment and to some of the responses of old and newly transplanted trees to fertilizer applications.

Aside from conditions caused by the work of parasitic insects or fungi, it is probably true that the vigor of the root system is largely reflected in the growth and luxuriance of the foliage for which we prize the tree. For this reason if we can supply the roots with the most suitable soil conditions we have greatly reduced our cause for concern about the state of affairs above ground.

As one writer has expressed it, there are six "factors" required for the growth and health of the higher plants. These are, light, heat, air, moisture, soil nutrients and mechanical support. When we consider that the soil supplies the tree with five of these, either wholly or in part, we can readily see the importance of root environment in the health of a tree.

TWO WHITE ASH TREES WHICH WERE GIVEN THREE ANNUAL FERTILIZER APPLICATIONS

Thousands of pages have been written about the effect of temperature, light intensity, air contents, humidity, etc., on the above-ground portions of trees and other plants. After all, there is really not much we can do to control these things under field conditions. But we can, within certain limitations, control soil temperatures.

By irrigation and drainage we can regulate the moisture supply. In a like manner we may influence aeration of the root area and by the use of fertilizers the needed elements may be supplied. With much of this you are, of course, familiar but let us look at it as it applies to practical tree problems along our drives, on the fairways, or about the clubhouse.

For example, if a tree has had half its root system removed in excavating for the basement or building the driveway, can we induce its roots to go twice as deep so that they will still be able to feed in the same volume of soil as they did before? We transplant large trees and in doing so we cut away the roots even more severely than we do in transplanting small trees. How can we restore and enlarge this root system rapidly in order to avoid pruning the top too severely? When our trees are suffering from poor soil conditions what fertilizers are usually needed and how may they be applied most efficiently to lawn or to other sod-grown trees?

AIR EFFECTS ROOT GROWTH

THE presence or absence of air rather definitely limits the downward growth of roots. Aside from the texture or fineness of the soil particles, aeration is quite largely influenced by the moisture supply. We cannot expect to induce deep and vigorous growth on our common trees in a soil with a high water table or a soil so nearly saturated that but little air movement can take place. It is true that trees may accustom themselves to such conditions but if an abnormally shallow root system results, the tree is always at the mercy of extremes of soil temperature in summer and winter, rapid changes of temperature in early fall, or severe and prolonged drouth.

Even such shallow-rooted and swamp-loving trees as larch and black spruce have been known to more than double their growth rate following drainage of their native swamp. In one of our own experimental plots a group of American elms, growing a few rods from the lake shore, increased its rate of increment decidedly during the drouth of 1930-1931, when the lake level was lowered appreciably. Thus we see that lowering the water table by encouraging deeper rooting may actually allow a tree to secure more water and so withstand drouth better than it would in a completely saturated soil.

Good drainage is especially essential for transplanted trees where copious and frequent watering is necessary. In fact where the soil drains freely, heavy watering may even assure good aeration. This can be readily understood when we remember that, in entering the soil, water displaces the air present and in draining out draws in a fresh supply of air. In addition, water from a hose or overhead sprinkler is charged with oxygen which is available to the roots. Thus we see that good drainage of transplanted or established trees is perhaps the first essential in our attempt to grow a new root system or to make an old root system less easily affected by moisture or temperature fluctuations or by restriction of root area.

Since many soils are more compact and less porous in the deeper layers and since we must oftentimes grow trees in soils none too well drained, what other means can we employ to insure good aeration in the deep layers? Cultivation has long been considered a means of introducing air to the soil. Research of recent years indicates quite strongly that stirring of the soil, aside from reducing weed competition for moisture and nutrients, has been overemphasized. It has been shown that vegetable and field crops having a wide and deep root system are less likely to be benefited by surface cultivation than are plants having a less extensive spread. It seems doubtful if surface cultivation would very greatly influence root conditions in the undisturbed soil layers 18 inches or more in depth. Furthermore, when our landscape picture is made on a carpet of green we do not take kindly to having patches of it laid bare in order that our trees may enjoy the benefits of cultivation. When methods of fertilizer application are discussed I believe some means of improving air conditions for our sod-grown trees can be pointed out.

AIR AND WATER ARE INSEPARABLY LINKED

SINCE the pore space of the soil contains both air and water, it follows that these two factors are inseparably linked. Too much moisture means too little air and too much air means a lack of moisture. From my casual contact with golf course problems I have the impression that a successful greenkeeper must be a master of the art of watering, but I would like to emphasize the fact that trees all too frequently do need aid in the form of artificial watering.

During a period of hot summer weather and light rainfall, trees soon exhaust the soil of its available moisture. Here again the deeper rooted trees have an advantage over those, which because of their shallowness are denied the moisture of the deeper soil. We should remember too that during a prolonged drought such as we had in 1930 the soil moisture is exhausted to a considerable depth and that even normal rainfall during late summer and fall may not restore the normal subsoil water content. For this reason, it may be necessary to water our trees even after our lawns and gardens have recovered from the dry spell.

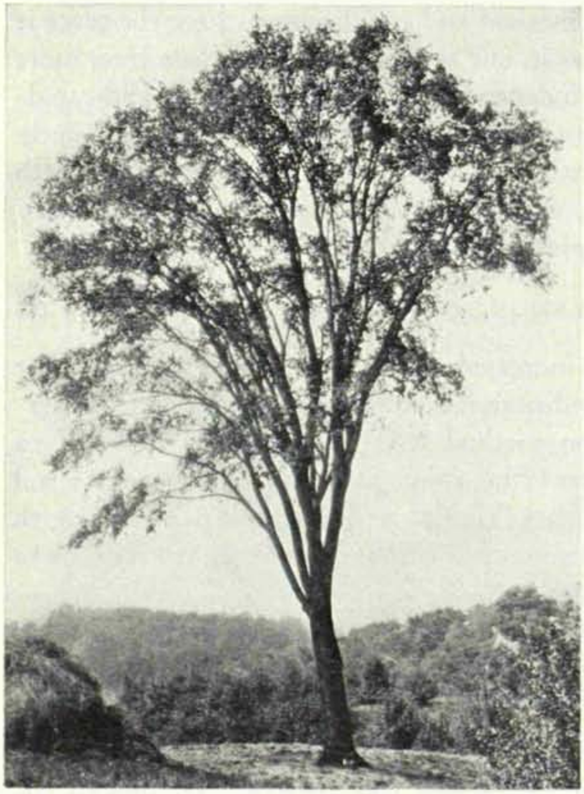
I had occasion during the past season to examine a number of dying white oak trees on the grounds of the Greenbrier Hotel at White Sulphur Springs, West Virginia. This was in the heart of the drought area of 1930 where for a period of six months during the spring, summer and fall there was not a single rainfall which could be measured in a standard rain gauge. Rainfall in 1931 up to the first of September had been about normal, and yet the resident engineer assured me that, with the exception of a few inches of surface, the soil at a depth of 12 feet was almost as dry as dust. This points out once again the value of prolonged irrigation over frequent light applications. Transplanted trees, which draw their moisture from a limited volume of soil, exhaust the supply rapidly and require more frequent but no less thorough watering.

When we consider the fertilizer requirements of shade trees we find that they grow in much the same way as other plants with which we are familiar. They use the same eleven or more chemical elements, though not necessarily in the same proportion. Many times the soil does not contain enough of one or more of these elements for trees, as is the case when we grow corn, potatoes, grasses or other farm and garden crops. We find that such crops do not all require fertilizers containing the same proportions of the needed elements.

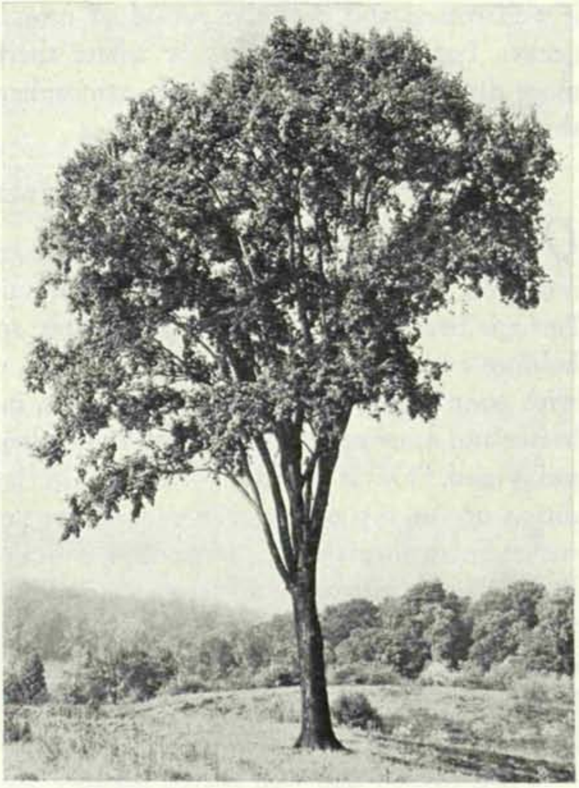
NITROGEN MOST IMPORTANT TREE FERTILIZER

TREES respond to the application of one element more readily than to others. Of the three elements supplied in complete mixtures, nitrogen is by far the most important in a tree fertilizer. There is much research work yet to be done on shade tree fertilizer problems but in the light of our present knowledge there is no reason for spending much of our fertilizer dollar for phosphorus or potash.

While nitrogen may be supplied in any one of a number of forms, a mixture of two or three forms should be used. Materials such as sodium nitrate are readily available but leach out so readily under certain soil and moisture conditions that they should not be depended on for the entire supply. On the other hand, straight organic carriers such as bone meal or cottonseed meal are rather slowly available and, even over a period of years, have not proved as efficient on deciduous trees as mixtures of both organic and mineral carriers. Trees make root growth and absorb food materials over a long season of the year and it seems advisable to supply them with a fertilizer containing both immediately and slowly available nitrogen.



AN AMERICAN ELM IN AUGUST, 1927, WHEN IT HAD RECEIVED ITS FIRST FERTILIZER TREATMENT



THE SAME ELM IN AUGUST, 1930, SHOWING THE BENEFIT OF THREE FERTILIZER TREATMENTS

In addition to the need for nitrogen, shade trees rather frequently lack a supply of available iron. The result is a deficiency disease known as chlorosis. It does not readily respond to soil treatment but is mentioned here because it is brought about by a soil condition. Most soils contain considerable quantities of iron. However, in the alkaline or less acid soils this may not be so readily available and as a result certain trees do not secure the needed amount of this element. This shows up in the tree as a yellowish condition of the leaves with green areas along the veins, in addition to the usual symptoms of starvation. Most of our ornamental trees do quite well in slightly or even strongly acid soils. For this reason it is well to avoid repeated use of fertilizers which tend to make the soil alkaline. These may be alternated with the acid residue materials or a mixture of the two types may be used. The chlorotic condition may sometimes be brought about by the use of alkaline water in artificial irrigation.

Manure or any other organic material, of course, plays much the same role in improving soil conditions for trees as it does for other agricultural or horticultural crops. If manure is used in transplanting or elsewhere, where it may be placed at any considerable depth and where the soil is likely to be quite moist, great care should be taken that it is well rotted and past the period of most rapid decay. For surface mulches or where there is a more direct connection with the atmosphere the shredded manures may be used.

USE PEAT MOSS FOR TRANSPLANTED TREES

ON TRANSPLANTED trees where rapid root growth is desired, peat moss seems to be especially suitable. Perhaps because it combines great water and air holding capacities this material even when mixed with poor subsoil, under some conditions, induces better and more rapid root growth than when topsoil is used. This is reflected, of course, in the condition of the top of the tree and results in more successful transplanting. Peat moss contains but little organic nitrogen and seems to decompose without the formation of harmful gases even when mixed to considerable depth in heavy soils. This, however, may be directly due to its effect on aeration.

When topsoil and well rotted manure are difficult to secure. a deep and favorable rooting area may be quickly prepared for transplanted trees, even in poor subsoil, by the use of peat moss. Where this is done, nitrogen fertilizers should be used from time to time throughout the summer. This is necessary to supply both the tree and the bacteria which decompose the peat moss and to take care of leaching under the frequent watering necessary for transplated trees.

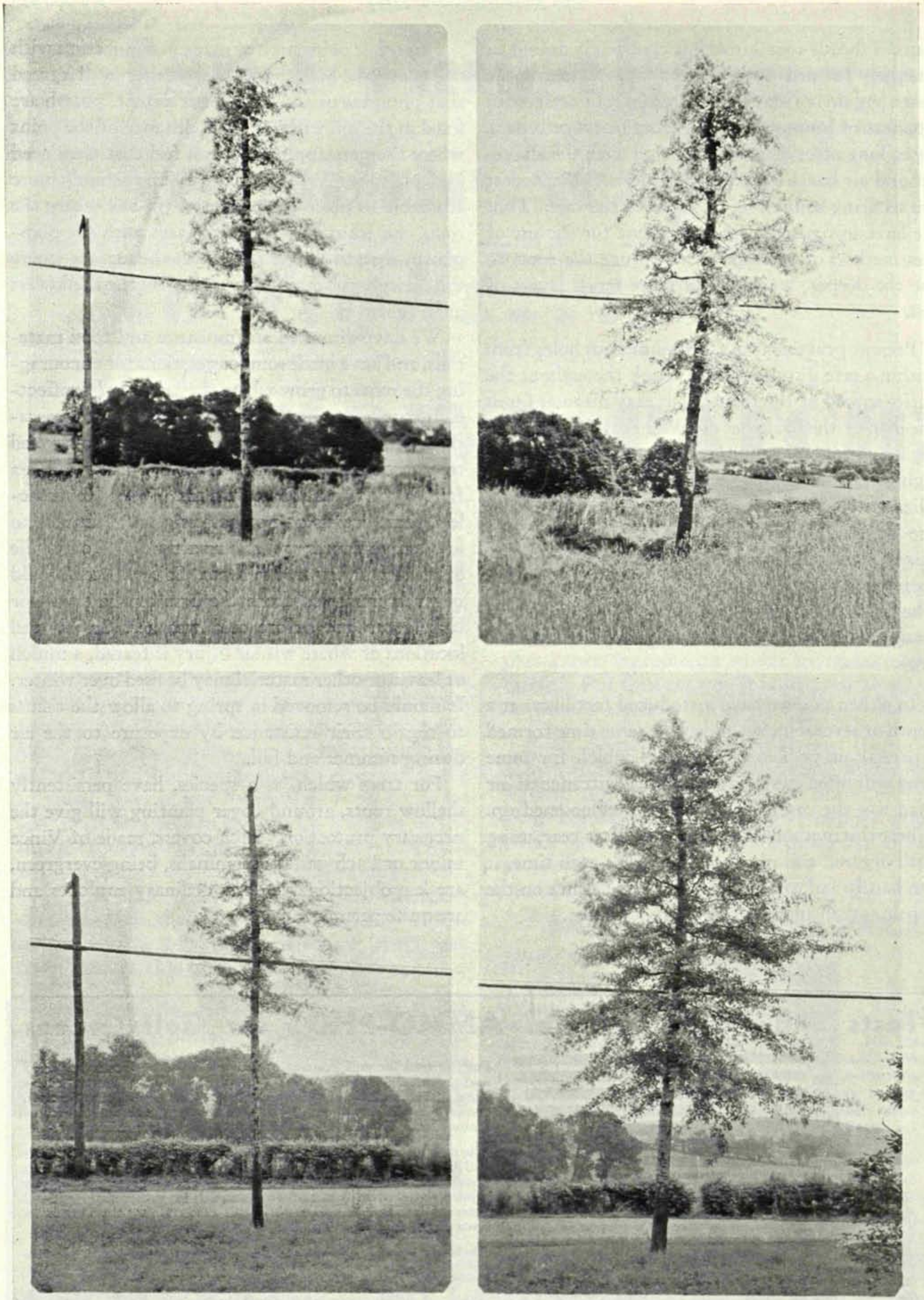
It has already been pointed out that cultivated areas are not welcomed in our grassy landscape scheme. Even more unwelcome is the idea of heaping the soil beneath our trees with manure to give them the benefit of organic matter. This method has a tendency to develop surface roots and since we try to avoid this it is time to consider methods of applying both chemical fertilizers and humus materials to ornamental trees under conditions which demand a minimum of disturbance at the surface.

The so-called crowbar or perforation system of applying fertilizers to trees has been used for many years. Originally a comparatively small number of holes was made under each tree. This method places the fertilizer below the grass roots and when carefully done it is not necessary to follow up with immediate watering as is necessary when mineral fertilizers are applied over the surface of the lawn. In more recent years, we have a newer conception of this method and a higher regard for the place it occupies in our attempt to make shade trees more nearly independent of irregular rainfall and rapidly changing soil temperatures. This is particularly true with the development of power driver earth augers, with which holes can be made more easily and rapidly than by hand.

PERFORATION METHOD INCREASES ROOT GROWTH

THE increased root growth which follows better soil conditions is common knowledge. By the perforation method it is possible over a period of years to bring about an improvement in the soil around large trees to a considerable depth and with a minimum of disturbance either to the roots or to the lawn.

Many of us have seen masses of fine roots following a crack in a clay subsoil, sometimes several feet deep. While the crack may have no visible connection with the surface soil, the better air supply permits or encourages this growth even though the surrounding undisturbed clay may be devoid of



THE TREES AT THE TOP ARE TYPICAL OF A GROUP SUFFERING FROM IRON DEFICIENCY IN JULY, 1929. THE ONE AT THE LEFT WAS NOT TREATED. THE ONE AT THE RIGHT WAS TREATED BY INTRODUCTION OF IRON SOLUTIONS DIRECTLY INTO THE TRUNK roots. Fibrous root growth is commonly found in channels formed by the decay of former large roots. Again we may find increased root activity in a pocket of humus, resulting from insect or rodent nests, long after direct connection with the above-ground air has disappeared. In all cases these roots are securing something of value to the tree. Thus we have in nature ample precedent for the use of this method of attempting to induce the roots to use the deeper, warmer and more moist layers of soil.

Present practice is to form numerous holes from within a safe distance of the trunk throughout the entire spread of the roots. This may mean as far as the drip of the branches or twice that far, depending on individual conditions. These holes are ten to eighteen inches deep or even deeper. Chemical fertilizers alone may be used and the hole refilled with the loosened soil. Usually the hole is filled with a mixture of chemical fertilizer and some humus forming material to within a few inches of the top. The hole is then filled to the top with soil to re-establish an immediate growing medium for the grass roots.

In either case we have introduced fertilizers at a depth of several inches and at the same time formed a partial air pocket and channel which for some time will offer less resistance to the entrance of air than was the case before the soil was loosened up. Where this method is repeated year after year, using both organic and inorganic materials each time, it can hardly fail to have a favorable influence on the depth, spread and vigor of the root system.

One other point may be made in connection with this method. Soil chemists are fairly well agreed that phosphorus and, to a lesser extent, potash are fixed in the soil within a short distance of the point where they are applied. If you feel that trees need high phosphorus fertilizers, then it is certainly more advisable to place them deep in the soil where the roots can actually come in contact with the phosphorus than to scatter them over the surface where the phosphorus may never go below the shallowest grass roots.

We have discussed air, moisture and food materials, and have made some suggestions for encouraging the roots to grow where they may be less affected by surface temperatures. Extremes of temperature, both winter and summer, can be controlled to a certain extent. Fortunately, a heavy sod is a fairly good protection to the tree roots. Nevertheless, these organs do not possess great resistance to low temperatures and as a result trees do often die of winter injury to the roots. Soil or litter should never be removed from the base of the trunk or large roots just before cold weather. In exposed locations or where winter injury is feared, a mulch of leaves or other material may be used over winter. It should be removed in spring to allow the tissues to regain their resistance by exposure to the air during summer and fall.

For trees which, as a species, have persistently shallow roots, ground cover planting will give the necessary protection. Such covers, made of Vinca minor or Pachysandra terminalis, being evergreen, are less objectionable than ordinary mulches and are quite permanent.