

to occur between strains of creeping bent grass. Just as differences in habit of growth, color of spores, or other major features serve to distinguish the species within a given genus, so differences in minor features within a given species serve to differentiate the individuals into strains. Thus while two strains of a fungus may be exactly alike in minute description, one may be only slightly parasitic while the other may be aggressively parasitic. In brownpatch wide differences in parasitism occur between the strains of the causal fungus, *Rhizoctonia solani*.

Environment Is an Important Factor in the Development of Disease

The importance of environment as a factor in the occurrence and severity of diseases can hardly be overestimated, since both the parasites and the host plants respond directly to conditions of environment. The fungus parasites have, for example, individual reactions to temperature. Nearly all fungi have a definite point below which they will not grow, known as the minimum temperature; a point at which they make their best growth, or the optimum temperature; and a point above which they will not grow, or the maximum temperature. The host plant also responds to changes in temperature, but its critical points of minimum, optimum, and maximum temperature may be quite different from those of the parasite. When the optimum temperature for a particular fungus is much higher than the optimum temperature for the host plant, and a temperature is reached which is favorable for the parasite but unfavorable for the host, the parasite grows abundantly, the resistance of the host may be decreased, and infection may occur.

Fungi likewise have optimum requirements as regards water, light, food, soil, and other environmental conditions which promote a rapid development of the organism. The host plants also respond to these same environmental conditions, and the resulting changes in growth help to determine in large part whether or not a host plant will be resistant to attacks of organisms in close proximity that are ready to attack.

Some Fungi Attack Many Plants

Some fungi are natural inhabitants of the soil, occurring widely distributed under widely varying environmental conditions, and are able to attack many different kinds of plants. The brownpatch fungus, *Rhizoctonia solani*, is one of these, attacking nearly 200 different species of plants. To some plants it may cause only slight injury, while to others it may cause death. It is one of the most common enemies of the potato. Species of *Fusarium* and *Pythium* are other examples of fungi capable of attacking a wide variety of plants. On the other hand, some fungi are selective in the plants they attack, a good example of this latter class being the smuts. Some species of smut fungus will attack only a single species of plant, as in the case of the onion smut, the wheat smut, and the corn smut.

NONPARASITIC DISEASES

Plants have certain fundamental requirements without which they can not live. These requirements include food, moisture, favorable temperature, light, and air. When any one of these factors is deficient or in excess the plant is unable to make normal growth, and if the extremes are too great the plant may die. Injuries thus caused are known as nonparasitic, or physiological, diseases.

Plants use simple materials which they absorb from the air or soil—carbon dioxide from the air and other necessary materials from the soil. Nitrogen, phosphorus, potash, and calcium are the most important of the latter from the fertilizer standpoint, since they are the elements in which soils are most frequently deficient. Other elements, such as magnesium, iron, and manganese are also important. When the soil is deficient in one or more of the nutritive elements the plants suffer and can be brought back to a healthy condition only by the addition of the deficient elements. A continuous supply of nitrogen is especially important for grass, since it is necessary for abundant leaf growth which is a requisite of turf.

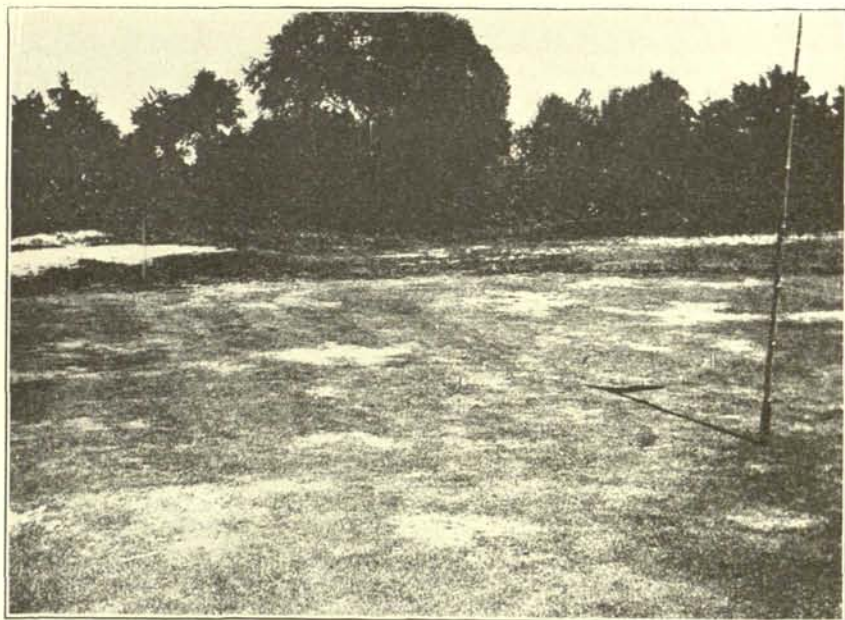


Figure 9.—An example of injury to turf by careless, uneven application of chemicals.

In order that plants may grow normally it is not only necessary to have available all the essential elements but there must be a fairly definite balance between them. If a soil contains sufficient of all the required elements to support a healthy plant and is then supplied with a great excess of any one element the favorable balance is disturbed and plant growth may be quickly checked. This balance of nutritive elements for plants may be compared in a general way with the balance needed to make a gasoline motor function properly. If there is a proper balance of spark, gas, and air the motor functions properly. Even though the supply of spark and gas, for instance, may be adequate, if an excess of air is introduced the favorable balance among the three is disturbed and the motor fails to function properly. The balancing of three factors in the gasoline motor is simple compared with the balancing of a large number of elements for plant growth.* Just as temperature and other factors influence the

favorable balance in the motor so temperature, rainfall, and many other conditions influence the balance in plant growth. Fortunately the soil with its various chemicals and microorganisms tends to keep the balance favorable in many cases. Under the extremely artificial soil conditions on most golf courses, however, it is easily possible to seriously upset the desired balance. For example, the more rapidly the plant absorbs nitrogen from the soil, the greater is the need for an increased supply of other elements, such as phosphorus, potash, and calcium.

Moisture also is an essential factor in the growth of plants. The limits of moisture are rather definitely fixed. When too little moisture is present in the soil the plants begin to wilt, and when there is too much moisture the roots are injured. Many crops are injured by an unbalanced water supply. The damage caused by excessive water is due to the replacing of air in the soil with water, leading to a deficiency of oxygen, which is essential for healthy root growth. Excessive water may also leach essential elements from the soil. A deficiency of water on the other hand may lead to too great a concentration of salts.

Light and a favorable temperature also are important factors in the growth of plants. Long cloudy periods and shading cause a yellowing and a weakened condition. After a period of shading, sudden exposure to bright sunlight is likely to be injurious. Changes in temperature may weaken the growth of plants. There are points above and below which plants can not live and there is an optimum temperature at which they grow best. The limits are rather wide for some plants, but near either extreme injury is apt to occur. The condition of the plant determines to a large extent the amount of injury which occurs from extreme temperatures. For instance, when a heavy frost occurs after plants have begun to grow in the spring and they are in a tender state, injury may often result.

Still other nonparasitic diseases result from direct injury to plants. An important example is burning the turf with chemicals, which frequently occurs on golf courses where insufficient care is taken in applying chemicals. Plants which are in a tender condition will not stand nearly as heavy applications of chemicals as when they are more hardy. Plants are more subject to injury from chemical burns in the summer, during the hot periods.

HISTORY OF DISEASE CONTROL

Since the dawn of history when men first noticed the occurrence of diseases in plants they have taken measures to alleviate or to prevent them. Blight and mildew were known in Biblical times. Aristotle discussed wheat rust in 350 B. C. At that time the causes of diseases were unknown and accordingly many superstitious explanations were offered. A variety of measures were taken to prevent or control diseases without any understanding of their true causes. Plant diseases were at first thought to be punishments inflicted upon the people by angry gods or malicious demons; accordingly prayers were offered and complex rituals performed to appease the gods or to frighten away the demons. These were probably the first attempts at plant-disease control.

Later treatments attempted during the early historic period were of a more practical nature. These were the results of trial-and-error methods, which in most cases were not effective. Some of these early