Known and Unknown Factors in Greenkeeping*

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Other papers on the program of this meeting offer experimental evidence of progress in the science of fine turf growing. The detailed study of different species of grass, of fertilizers and soils, and of pests and diseases affecting grass are rapidly substituting for the mysteries of turf management a knowledge of the essential factors. It would be a short-sighted policy, however, to close our eyes to important experiments and discoveries seemingly entirely apart from experimentation upon the problems of golf courses. Many of the discoveries of the last few years contain suggestions that may advance our experimental work.

Of course, no one yet understands much about soils, but some things at least are better understood than they were a few years ago. For example, a fertile soil is not a dead mass of nondescript material. All fertile soils are full of living things; literally millions in each cubic inch, and of these many millions there are hundreds of different kinds of bacteria, molds, microscopic worms and other animals. If we kill all of these living organisms in the surface foot of soil by heat or poison, neither grass nor other plants can grow properly in this dead soil. Usually a sterilized soil can be restored to fertility by mixing with it either a little fresh "live" soil or manure. The value of the manure undoubtedly is due in such a case to the enormous number of bacteria and fungi it brings to the dead soil, but whether the bacteria in manure are equally beneficial when put onto a good "live" soil we do not yet know. We do know, however, that manure has a value in increasing the growth of most plants, including grass, that is remarkably in excess of the plant food percentages determined by fertilizer analysis. It seems reasonable to ascribe this benefit, at least partially, to the decaying and nitrifying bacteria and fungi in manure.

Recent studies of plant food minerals essential for plant growth suggest another partial explanation. It is now clear that plants as well as animals have very exacting requirements for minute quantities of certain minerals, in addition to the three so-called fertilizer elements for growing plants. Traces of manganese, magnesium, calcium, iron, sulfur, and iodine are absolutely necessary for normal growth of many, if not indeed all, plants, but the amounts needed vary with different plants. The unusual value of manure may thus be due partly to traces of these essential chemicals, and if we learn the food needs of our turf grasses more thoroughly we may be able to mix fertilizers even more satisfactory than any now made for grasses. Not only these mineral foods, but the acidity of a soil, determine what plants thrive best in it. Some plants can grow only in an acid soil, some only in a neutral one, or one high in lime, while others, such as the bent grasses, can grow in all of these conditions. Most of the weeds troubling golf courses, however, are at their best in the lime soils. The extent to which the lime-loving weeds can be discouraged by the use of acid fertilizers, such as ammonium sulfate, or by aluminum sulfate, is yet to be determined, but the results so far seem very promising. In adding these materials or, in fact, any other fertilizers or other salts to the soil, changes in the composition of the soil are brought about which are but imperfectly understood. Soils even of apparently similar texture and composition may

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differ widely in the extent to which different bases in the soil may be replaced by materials added, and these differences in the behavior of the mineral compounds of the soil almost certainly are reflected also in the biological conditions of the soil.

Clays especially are but little understood. Chemically, to be recognized as silicates of aluminum, they are capable of varied composition, including traces of calcium, iron, and other elements. Clay soils are generally said to be difficult to handle, and many reasons have been suggested. The puddling of clay when it is wet is well known, but whether walking over a wet course results in puddling the surface, except in very extreme cases, is doubtful. It is probable that heavy rolling of a wet course will compact a true clay seriously, and might even puddle almost bare areas. The essential thing, where it can be accomplished, is to incorporate sand, manure, or other vegetable matter in the clay so that it will flocculate or break up readily upon drying. If the soil regains a proper tilth upon drying it will not be injured by rolling. A soil surface which will not cake is a matter of importance in "taking" water when sprinkling grass, as well as in avoiding the hard surface of a fiery green.

Hard soils are due primarily to a lack of proper flocculation of the soil particles. In clays, the flocculation brought about by the incorporation of vegetable matter not only improves the flocculation of the clay but provides additional spongy or friable material, and therefore improves the yielding or springy character of the surface layer. The excellent springiness of natural soils composed largely of vegetable peats has suggested the use of peat mixtures with clay to improve the physical texture of clay greens. These mixtures have not proved especially satisfactory, and from the above lines of reasoning it appears that the unsatisfactory character of these mixtures may be due to the lack of soluble mineral elements in the peat, and accordingly its comparative lack of effect upon the composition of the clay materials. Peat mixtures with clay are apt to be streaky, the clay not mixing at all readily with the peat. On the other hand, the mixture of manure or of green manures with clay soils, even in lesser quantities, does materially improve the degree of flocculation and thus makes possible both the better aeration and more satisfactory absorption of water.

That a hard and fiery green is hard on the grass is obvious. Whether the injury to the grass is largely starvation for lack of proper plant food and of a steady water supply, is not so certain. That aeration was inadequate has been suggested; that may have some effect, for some plant roots are very sensitive, while others can stand being either under water or sealed in soil almost indefinitely. Rice, for example, will germinate and grow under water, although most seeds can not either germinate or grow properly unless they have an adequate air supply. Grass seeds are quite sensitive to a lack of air supply; but it is not known how extensively this limitation applies to the vegetative stage of bent grasses.

The difference in the effectiveness of watering by sub-irrigation and by sprinkling has been ascribed to the better aeration likely to obtain in the case of sprinkling. Although sprinkling appears to be a more satisfactory method of watering for grass and some other plants, it is possible that this may be due to stimulating the aerial portions of the plants rather than by changes in the air supply of the roots. Among the possibilities that should be investigated are the stimulating effects of carbon dioxid, which might be incorporated in the sprinkling water.