best greens. The soil should be well mixed and free of layers. Moisture movement both up and down is hindered in layered soils.

The grasses of the best greens have a better root system than have those of the poorest greens. No conclusions could be drawn as to the effect of soil layers on the distribution of roots.

As a rule, the best greens are in more favorable locations than the poorest greens. In most instances air circulation is believed to be better around the best greens. More trees are found around the poorest greens, and tree roots are prevalent in these greens. If landscaping of a golf course makes it necessary to put trees near greens, the trees should be open types. Steps should be taken to see that all roots from trees are blocked from the green. Tree roots give the grass on greens much competition for water and minerals and make the control of these factors more critical.

The soil reaction is generally more alkaline or less acid than the optimum reaction for the growth of bent grass. Alkaline conditions are thought to be due to alkaline sand in topdressing materials and alkaline water for irrigation. The pH is higher in an area 4 to 8 inches from the surface than in an area 1 inch to 4 inches from the surface. It is also higher in the best greens than in the poorest greens. If a green is alkaline, acid fertilizers and acid topdressing should be used where possible.

Phosphorus is very high and potassium is low in most greens. This condition is probably due to the use of mixed fertilizer with a high ratio of phosphorus and relatively low ratio of potassium, as well as leaching and replacement reactions affecting the potassium supply. The phosphorus and potassium contents of the greens are positively correlated. Both phosphorus and potassium are higher near the surface than they are 4 inches to 8 inches down. Both are also higher in the poorest greens than in the best greens, probably because more fertilizer is applied to the poorest green in an effort to stimulate unhealthy turf. If mixed fertilizers are to be used on greens, one with a high ratio of potassium to phosphorus should be used. Perhaps a better solution is to use unmixed fertilizers as needed according to past experience or the results of soil and tissue tests.

The USGA Journal of June 1949 *reported results of study of cores of soil from best and poorest greens.*

Permeability of Various Grades of Sand and Peat and Mixtures of These With Soil and Vermiculite

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A review of the literature reveals that very little information is available on the permeability of mixtures of materials which are used in the construction of special-use areas such as golf greens. Since such areas are subjected to extreme conditions of management and use, information is needed on the effect of compaction on the permeability of materials that are used in their construction and maintenance.

During August, 1948, a preliminary survey was made on 10 golf courses in Oklahoma to obtain information on the physical characteristics of greens that have been in use for many years. The mechanical analyses of the samples collected showed that the average clay composition of the surface 6-inch layer was 5 per cent. Many of the greens contained less than 3 per cent of clay. Under these conditions it was not surprising to find occasional chlorosis, poor growth and moisture deficient areas.

Various soil-sand-organic mixtures have been suggested as being available for the growth of grass on greens, but little experimental information has been reported to verify these suggestions.

Since favorable air and water movement through the soil is required for the growth of good turf, it was the purpose of this study to make permeability measurements under varying degrees of compaction on materials that are commonly used in green construction.

There are three materials which reduce water movement in special use mixtures. These are silt, clay and peat. Thus a soil which contains a high percentage of silt may reduce the permeability of a mixture in a manner similar to that of too much clay or peat. Since the silt fraction does not possess base exchange properties which are important to a mixture used for turf production, a soil moderate in clay and low in silt would be preferred. When available, a soil which contains 20 to 35 per cent of clay and more sand than silt should be selected for use in such mixtures.

The results reported herein show that a mixture containing equal volumes of sand, soil and peat does not possess adequate permeability after compaction at high moisture levels. Vermiculite, when substituted for peat, showed higher permeability under this type of compaction. No justification could be seen for using either peat or vermiculite in excess of 20 per cent of the total volume of a mixture. A mixture with a clay content of between 5 and 10 per cent should prove favorable to withstand hard usage under wet compaction. The mixture which contained 8.2 weight per cent of clay and 20 volume per cent of peat maintained favorable permeability in resistance to severe treatment. It is believed that such a material should prove satisfactory for the growth of good turf under a wide range of conditions. If vermiculite is used, there appears to be little justification for making a mixture which contains more than 9 per cent of clay.

Even though nothing has been said here about the subgrade of a green, it is important to remember that the most ideal surface mixture will prove unsatisfactory without good subsurface drainage. It has been shown that too frequently those in charge of special use areas try to alter the surface mixture to alleviate a condition which exists in the subsurface zone.

In summary:

(1) Permeability measurements show that coarse silt particles restrict water movement to less than 0.9 inch per hour when in layers 2 inches or more in depth.

(2) Peat when compacted at field capacity becomes almost impervious when in layers 6 inches in depth.

(3) In soil-sand mixtures, those containing 5, 10 and 15 per cent of clay restrict water movement to 4.1, 0.35 and less than 0.1 inches per hour.

(4) A mixture of equal volumes of sand, soil and peat had a permeability of 0.2 inch per hour when compacted at near field capacity. This was not considered adequate.

(5) A soil-sand-peat mixture containing 20 volume per cent peat and 8.2 weight per cent clay had a permeability rate of four times that of the 1-1-1 volume ratio mixture. This rate (0.8 inch per hour) is thought to be satisfactory and desirable for such special use areas.

(6) A vermiculite-soil-sand mixture (1-1-1 ratio) showed higher permeability and more resistance to compaction than a peat-soil-sand mixture (1-1-1 ratio).

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