PRINCIPLES OF SOIL PHYSICAL AMENDMENT

by Art Spomer

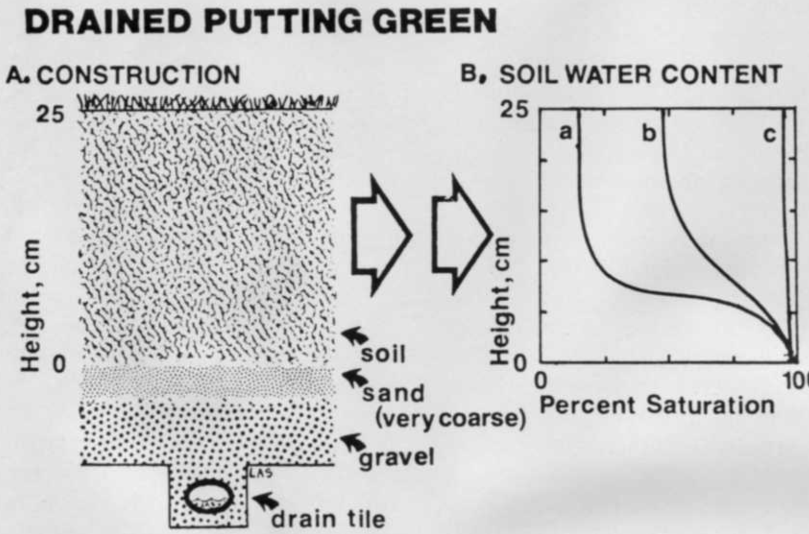


Figure 1. Water distribution pattern (B) for three different soils in a typical drained putting green (A). Soil 1 = coarse-textured sand; 2 = fine-textured sand; 3 = silty clay loam. All three soils are saturated at the drainage level (perched water table) and water content decreases with height above this level.

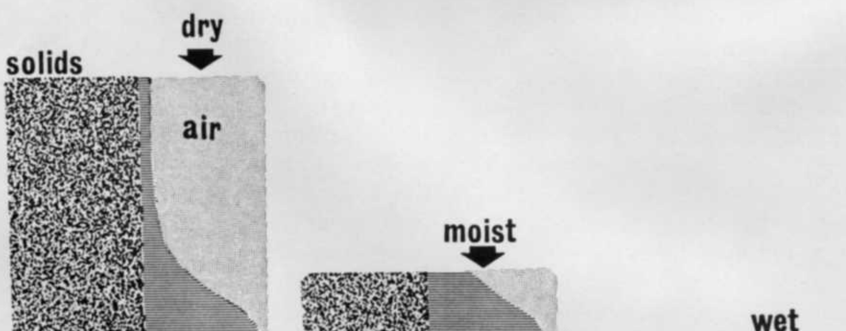


Figure 2. Effect of green drainage depth on soil water content. A shallower soil always has a greater water content following irrigation and drainage than a deeper soil.

Water is quantitatively the most important nutrient required for plant growth and survival. Actively growing grass tissue consists of about 90 percent water by weight.

Plants not only contain large quantities of water, they also usually require hundreds of times this amount during growth. This enormous amount of water contained and used by plants is more than just an inert filler, probably every plant growth activity is directly or indirectly affected by water. All of this water is absorbed from the soil through the plant's root system.

Since water is very essential for plant growth, and since all of the water used by plants comes from the soil, any factor affecting the absorption of water will, therefore, probably affect plant growth.

A number of biological, chemical and physical factors directly and indirectly affect either soil water retention and movement, or plant root growth and absorption. The primary soil physical factors affecting plant water absorption are soil water content and soil aeration.

Water content is important because it indicates how much water is potentially available for plant use.

Soil aeration (the exchange of oxygen and carbon dioxide between the soil and above-ground atmosphere) is important in maintaining a constant supply of the oxygen required for good root growth and absorption. Both aeration and water retention depend primarily on soil structure which is determined by the kind and arrangement of particles in the soil.

Most golf greens have two important features which distinguish them from other golf course turf sites:

1. They are subject to severe

Continued on page 28

SOIL AMENDMENTS

Continued from page 26

foot and mower traffic, and

2. they are drained.

The effects of the traffic are obvious (soil compaction, poor root growth and absorption); however, the effects of the shallow drainage (excess soil water content, poor soil aeration) are less obvious but are generalized in Figure 1. A perched water table forms at the drainage level in such a green following irrigation and drainage. Under these circumstances, any good, medium-textured natural soil will likely be saturated throughout (Fig. 1-B) and grass growth will probably be poor.

Both problems are minimized in practice by amending the soil with coarse-textured materials (e.g. bark, calcined clay, gravel, perlite, sand, scoria, vermiculite, etc.) to increase the soil's resistance to compaction and to increase the amount of large aeration pores which drain despite the water table. Unfortunately, "too little" amendment reduces both soil aeration and soil water retention without increasing the soil's resistance to compaction and "too much" reduces water retention excessively.

The "optimum amount" of soil amendment should maximize soil compaction resistance and at the same time provide soil aeration and soil water retention which closely match those required for good turfgrass growth and water absorption.

This article briefly discusses the changes in soil physical properties when natural soils are amended with coarse-textured materials.

Soil Amendment — soil physical changes

Figure 4 "pictures" what happens as a coarse-textured amendment is mixed with soil in increasing proportions. Since soil mixtures are usually prepared from bulk quantities (e.g. bu. ft.^{3}, lit,m^3,yd^3 etc.), component and mixture quantities are herein expressed as

Continued on page 31

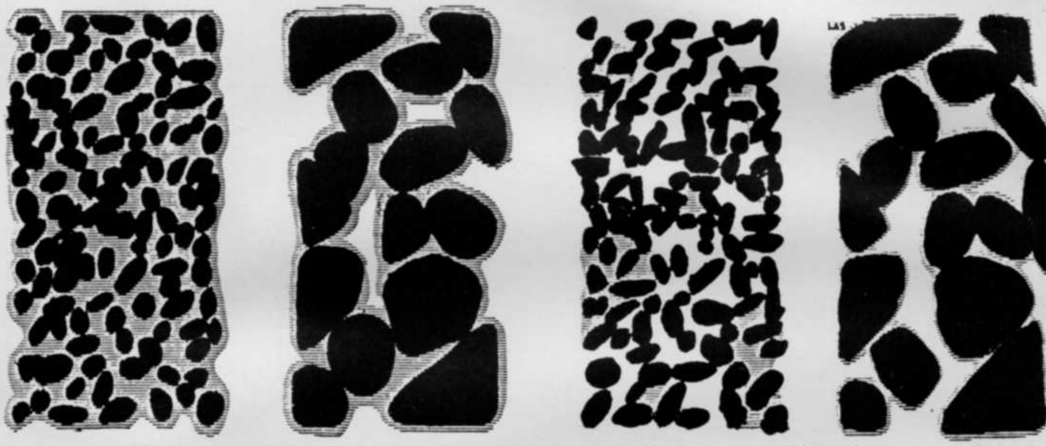


Figure 3. A drained green soil, left, is always wetter than that same soil in a fairway, right, following irrigation and drainage.

Effect of Amendment on Soil Porosity

AMOUNT OF SAND, SOIL & PORES (yd^3 in ten yd^3 mixture)

soil	10.	7.7	5.5	3.6	2.5	1.5	0.
sand	0.	3.5	7.	10.	10.	10.	10.
pores	5.	3.9	2.8	1.8	2.4	2.9	3.6

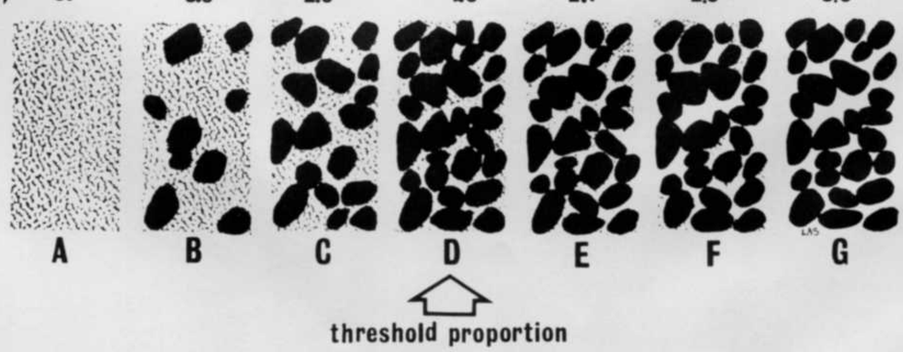


Figure 4. Microscopic "picture" of what happens to soil porosity as a coarse-textured amendment such as sand is added to the soil in increasing proportions.

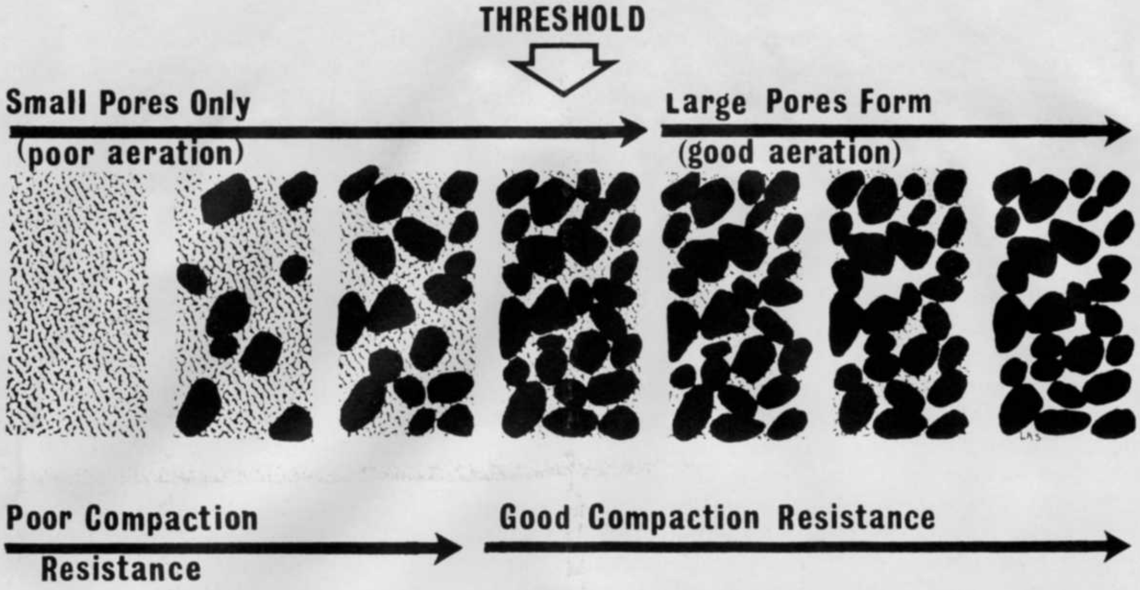


Figure 5. Generalization of what happens to soil porosity as a coarse-textured amendment is added to soil in increasing amounts (see Figure 3).

SOIL AMENDMENTS

Continued from page 28

bulk volumes. Bulk volume equals the total volume (solid + pore volumes).

Beginning with 100 percent soil (10 yd^3), mixture porosity first decreases then increases with the addition of sand in increasing proportions. Porosity initially decreases because the sand floats in the soil or excludes soil and soil porosity without adding any large pores.

The minimum porosity occurs at the threshold proportion which is the mixture in which the "mixing bin" or green excavation is exactly full of sand and the large pores between the sand particles are exactly full of soil. In other words, the threshold proportion is determined primarily from the amendment's interporosity. This is called the threshold proportion.

Since at the threshold proportion the amendment particles first exhibit particle-particle contact, this sets the limits for the amount of amendment required to improve the soil's resistance to compaction. As the proportion of sand is increased beyond the threshold, the large pores between the sand particles (amendment interporosity) become voided of soil and both total and aeration porosity increase (Figure 5).

A simple mathematical model can be used to predict mixture total and aeration porosities. This theo-

Continued on page 32

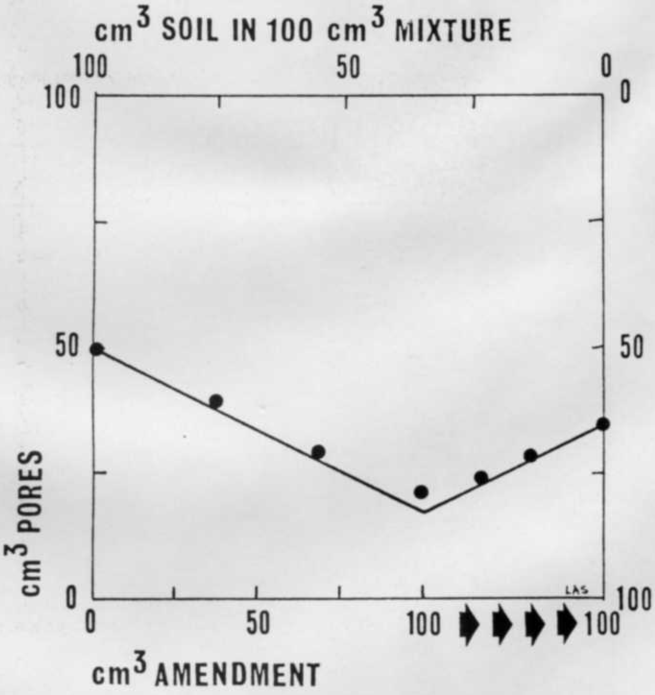


Figure 6. Theoretical (line) and actual (dots) porosity in soil mixtures containing different amounts of sand.

SOIL AMENDMENTS

Continued from page 31

retical model is compared with actual, total and aeration porosities of selected sand-soil mixtures in Figure 6. This data demonstrates that the theory accurately predicts the mixture's physical properties.

A simple graphic method for predicting soil total and aeration porosities from component individual porosities and bulk volumes has also been developed by the author and will be published at a later time.

The effect of pore size on soil water distribution in a drained putting green is illustrated in Figure 1-B. In general, soils with smaller pores (soil) retain more water in the upper levels than those with larger pores (sand). The effect of different amounts of soil amendment on soil water distribution in a drained area is illustrated in Figure 7.

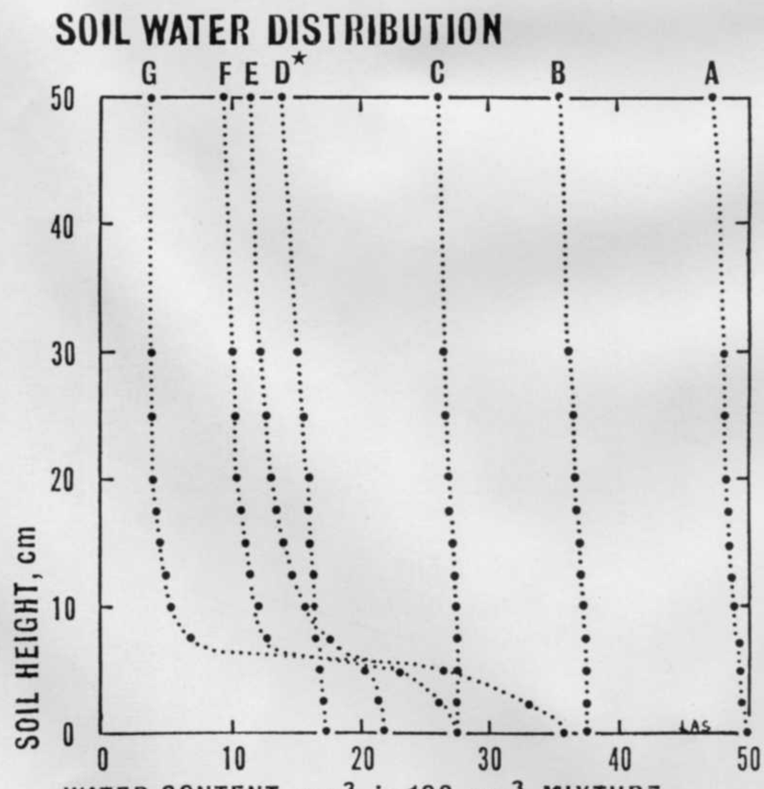
The addition or amendment (sand) up to the threshold proportion has no effect on the water distribution pattern, it merely decreases the total porosity. However, when more amendment than the threshold is added, the water distribution pattern changes to that typical of the sand indicating that large pores have been formed and that aeration should increase. As amendment particle size decreases, the soil water distribution pattern shifts towards the upper soil levels.

When selecting an amendment, it is usually best to use one which has a relatively narrow range of particle sizes. Well-graded amendments with large amounts of fine-textured particles should be avoided because they are generally less efficient (larger amounts are usually required to produce soil physical improvement). Particle shape also affects amendment efficiency, but is much less important than size and size distribution.

This article does not recommend any specific putting green soil mixture, but briefly describes what happens when an amendment such as sand is added to a soil. The "take-home" lesson is that a certain minimum proportion of amendment, the threshold proportion, is required before soil physical improvement is affected and this amount is usually quite high (75-90 percent of the total bulk volume of components).

The optimum soil mixture depends on soil, amendment, climate, drainage depth and plant species and is therefore difficult to determine without professional assistance. □

Art Spomer is associate professor of plant pathology in horticulture at the University of Illinois, Urbana.



BULK VOLUME, cm^3 in 100 cm^3 MIX

soil	sand	pores	mix
100	0	50	A
77	35	39	B
55	70	28	C
36	100	18	D*
25	100	24	E
15	100	29	F
0	100	36	G

*THRESHOLD

Figure 7. Water distribution patterns of different sand-soil mixtures in a drained putting green.