Soil Amendment: Soil Physical Change[1]

by **L. ART SPOMER,** Assistant Professor, Department of Horticulture and Illinois Agricultural Experiment Station, University of Illinois, Urbana, Ill.

Soil amendment and soil mixtures are essential for green construction and maintenance. Much excellent information has been published on this subject by the USGA and others. Too often however, these articles detail what to do but not "what happens" when it is done. This article briefly describes the changes in soil physical properties when soils are amended.

Soils are amended to resist compaction and assure good drainage. In other words, amendments are used to produce or maintain sufficient soil porosity to ensure adequate aeration for turfgrass growth and maintenance. Soil porosity consists of large or macropores (noncapillary) or small or micropores (capillary). Macropores are the "aeration pores" which empty or drain rapidly even under the shallow perched water table prevailing under drained greens while micropores usually remain water-filled following drainage. A disturbed or compacted field soil usually contains few macropores and therefore provides poor aeration. On the other hand, a good amendment such as a monodisperse (single particle size) coarse-textured sand has almost 100 per cent macropores. A golf green requires a compromise between these two extremes, and this is usually achieved by mixing a coarse-textured amendment with the soil.

Figure 1 illustrates what happens to soil porosity when a coarse-textured, monodisperse sand is mixed with a soil in increasing amounts (left to right). The total or bulk volume of this mixture is a constant 10.0 cubic yards (yd^3). Beginning with 100 per cent soil (100 per cent micropores; poor aeration, good water retention), adding sand first decreases porosity to a minimum (dashed vertical line) then increases it until the "mixture" is 100 per cent sand (100 per cent macropores, good aeration, poor water

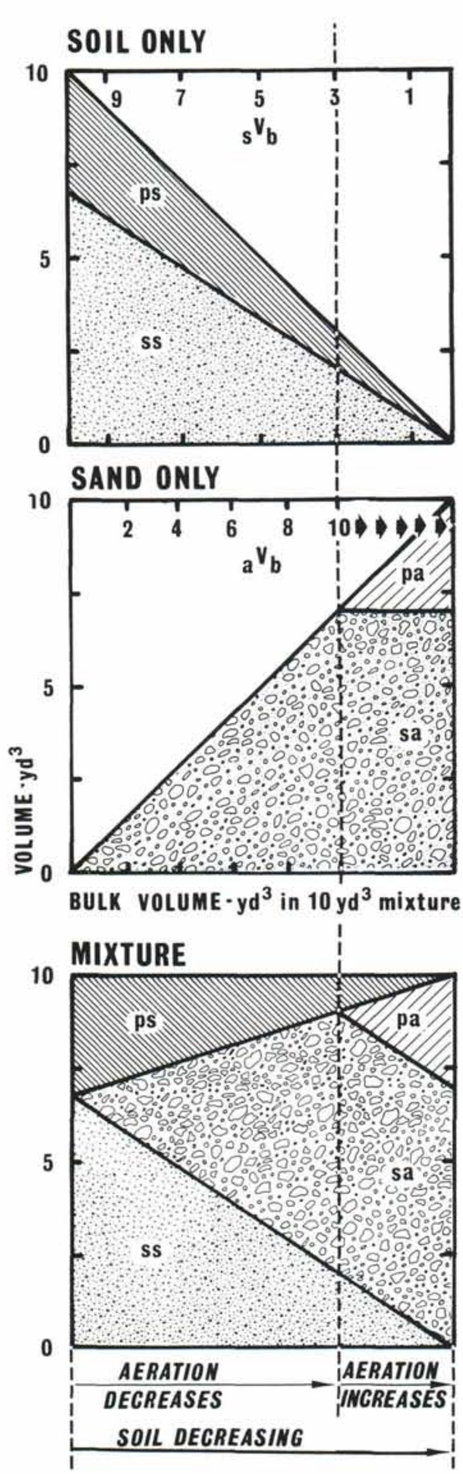

Figure 1. The effect of increasing amendment on soil and amendment solid (ss,sa) and pore (ps, pa) volume and their contribution to the mixture total. Sand was added to soil in increasing proportions with the mixture bulk volume remaining a constant 10 yd^3 (left to right). Sand and soil bulk volumes change at different rates. At the threshold proportion (dashed line), 10 yd^3 of mix contains 3 yd^3 soil + 10 yd^3 sand. If the proportion of soil is reduced from the threshold, large pores begin to open up (pa) and aeration should increase.

retention). The mixture having the least porosity is called the *threshold proportion*[2] because it represents the minimum or threshold amount of amendment required before soil physical improvement is effected. The threshold proportion, probably the worst possible soil mixture for plant growth, actually contains 10.0 yd^3 sand which is at its closest packing, but the macropores between the sand particles are exactly filled with 3.0 yd^3 soil. In other words, 10.0 yd^3 sand was mixed with 3.0 yd^3 soil resulting in only 10.0 yd^3 mixture and since the macropores are filled with soil, the only pores in the mixture are the small pores in the 3.0 yd^3 soil. Sand at less than the threshold "floats" in or occupies soil volume without forming macropores. If the proportion of soil is reduced from the threshold, macropores gradually empty and aeration and resistance to compaction increases. The threshold proportion is determined by amendment macroporosity (in this example: macroporosity = 3.0 yd^3 pores per 10.0 yd^3 sand; threshold proportion = 10.0 yd^3 sand + 3.0 yd^3 soil). Factors increasing amendment macroporosity (e.g. particle size distribution, shape) increase amendment efficiency; lesser amounts of amendments with high macroporosity are required to provide good aeration. Well-graded or polydisperse materials (contain a wide range of particle sizes) are poor soil amendments because they contain much fine-textured material which, like soil, fills the macropores and reduces aeration. More-rounded amendments (e.g., river sand and gravel) tend to pack more tightly and therefore have a lower macroporosity and are less effective as soil amendments than more-angular amendments (e.g., crushed sand and gravel, bark, sawdust, peat). Some soil-amendment combinations tend to separate by washing and settling or may compact with time and therefore are not suitable for long-term applications such as green construction. Any testing of soil mixtures should be done on compacted samples since this best approximates long-term use.

In summary, this article does not recommend any specific soil mixture for greens 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 effected and this amount is usually quite high (75-90 per cent of total bulk volume of components). The optimum amendment proportion depends on the soil, amendment, climate, and plant and is therefore difficult to determine without professional assistance.

[1] Portion of Dept. Hort. and Ill. Agric. Expt. Sta. Proj. No. 65-353.

[2] Spomer, L.A. 1974. Optimizing container soil amendment: the "threshold proportion." *HortScience* 9 (in review).

ABOUT THE AUTHOR

L. Art Spomer is Assistant Professor of Plant Physiology in Horticulture at the University of Illinois, Urbana, and is responsible for teaching and research in Horticultural Crop Physiology. Dr. Spomer received his B.S. from Colorado State University and M.S. and Ph.D. from Cornell. His current primary research interests are plant water stress and container plant-soil-water relations (quite similar to drained greens). He is currently involved in a USGA Green Section study of turfgrass water stress resistance.