How Dry is Your Soil?

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How dry is your soil? If we bet that you didn't know the answer to this question, odds would be in our favor. How "dry," or "wet," a soil is depends upon how much water is present, and how much of the total pore space is occupied by that water.

This lack of knowledge is astonishing in view of the duration we have been growing plants. However, there are good reasons for it. Plants have the ability to "adapt" to adverse conditions. The soil will stand considerable abuse and still support a plant. Similarly, by experience a grower learns that at this stage of growth, at this soil consistency, and under these environmental conditions, water should be withheld or added. Lastly, determining the amount of water is not the simplest process. We have instruments that we can stick into a bench that will give readings. But these instruments merely tell how tenaciously the soil is holding water—*not* how much there is. A tensiometer must be calibrated before a reading can be considered as a direct indication of water content.

In previous bulletins, we have shown that the amount of water in a soil influences growth. On the basis of research to date, when the amount of water exceeds 40%, or is less than 15%, of the total soil volume, growth will be reduced. As a general rule, 30% seems best. Obviously, a soil possessing 30% total pore space (air plus water) and 30% water is not well aerated. So we must also state that 50% of the total pore space in a given soil should be filled with air. It is our experience, that greenhouse soils which have been suitably modified and maintained will seldom possess a total pore space less than 50%. Many of our artificial mixes (for example peat-perlite) may have a total pore space of nearly 80%. For the present, we may neglect the problem of air-filled pore space since, if we maintain a proper moisture content, the amount of air-filled pore space will be sufficient.

The determination of water content in a soil on a volume basis is simple in theory. It consists essentially of removing an *undisturbed*, known volume, of soil from the bench and measuring its loss in weight (water) when dried. Just because a tensiometer reads 50 in 2 different soils, does not mean that both soils will have the same moisture content. If, however, the tensiometer is in the same general area as that from which soil samples are taken for moisture determination; the instrument can be

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read, and this reading is an indication of water content at a future date in that soil.

The difficulty in the process lies in removing an undisturbed sample. Compaction of the sample is the most serious problem. With care and practice, error in moisture determination from compaction of the sample can be reduced to negligible proportions.

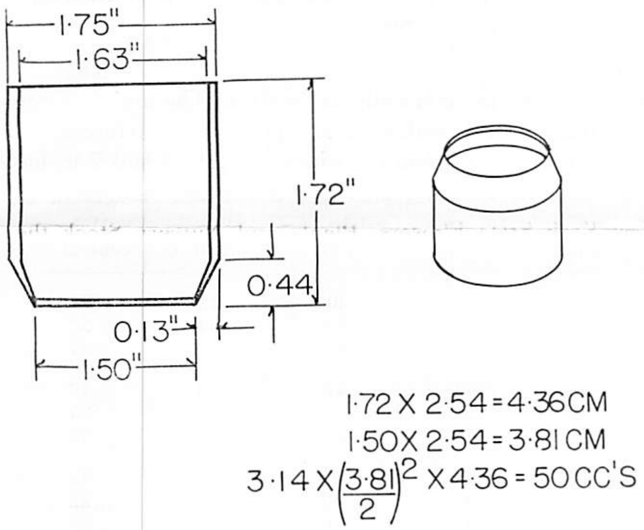

Figure 1: Drawing of core sampler used in moisture determinations. Dimensions are such to give a soil volume of 50 cc's. Made from 1¾ inch O.D. rigid electrical conduit. Smaller opening on cutting end is turned in on a lathe.

The tool we use is called a "core sampler," and Figure 1 is a drawing of one kind we have employed. It consists of a short piece of 1¾ inch O.D. rigid electrical conduit. The most important feature is the sharp end, the opening of which is made smaller than the rest of the tube. By making the opening, through which the soil sample must pass smaller, compaction of the sample due to friction on the walls of the tube is reduced. The tube is pushed into the soil until the upper edge is flush with the soil surface (Fig. 2). Uusally, the soil surface inside the tube will be lower than the surrounding surface. This may be due to compaction of the sample within the tube, or in the soil ahead of the tube. If pushed further to completely fill the tube, the same process should be employed on all soil cores. The core sampler is then carefully withdrawn. Difficulty will be encountered in very wet or dry soils, and it may be necessary to insert something under the cutting end of the tube to avoid losing the soil core. Figure 3 shows the core, core sampler and the hole made in the process. Once a good core has been obtained, it may be knocked out into a small pan, and another soil core taken with the sampling tool.

The dimensions of the sampler in Figure 1 give a soil volume of 50 cubic centimeters (cc). This can be increased to 100 cc's by doubling the length, but may result

Figure 2: Sampler in position for removing soil core. Top edge flush with soil surface.

Figure 3: Soil core, empty coring tool and hole made in process of removing sample.

in greater compaction. The sample is now weighed as indicated in Figure 4. The small aluminum trays are obtainable at hardware stores. An ordinary spring dietary scale (Fig. 4), marked in grams, is used. A post office scale can be employed, but the reading in ounces must be converted to grams (1 ounce is approximately equal to 28 grams).

The weight of the fresh sample is recorded and then the soil is placed in an ordinary oven regulated at 220 to 230°F for at least 6 hours, preferably 12. After the water is driven off, the sample is weighed again. If the 2 weights (wet and dry) are in grams, the difference between them, in grams, is equal to the cc's of water originally present. For example, a loss in weight of 15 grams means that 15 cc's of water were originally present in 50 cc's of soil. Therefore, 15/50 X 100=30%—or more simply, 2 x 15 =30. For every 100 cc's, or cubic inches, or cubic feet, etc., of that particular soil, 30 cc's, or cubic inches, or cubic feet, etc. was water.

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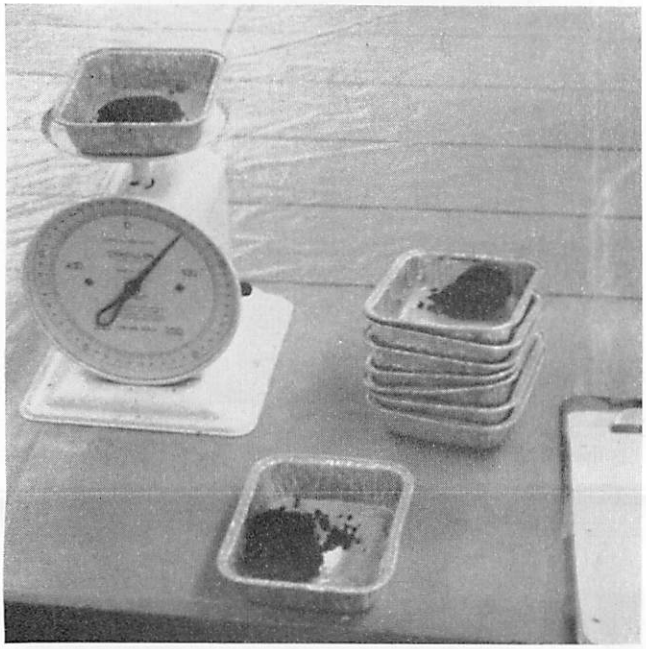

Figure 4: Weighing of fresh soil samples prior to drying at 220-230°F. Dietary scale, marked in grams, can be purchased for about $11.00.

If at the time of sampling, we have a device such as the tensiometer in Figure 5 located nearby, we can record the reading. The actual data obtained in a calibration curve at different tensionmeter readings are shown in Table 1. It will be noted that 3 samples were removed at each reading, in order to allow for variations in sampling procedure and in the soil. By means of the data in Table 1, we can draw a calibration curve as indicated in Figure 6. Instead of actually sampling the soil as we have described, we can now read the tensiometer, look at the calibration curve, and determine directly the amount of water present in our soil. This curve, however, is valid *only* for that particular soil under similar conditions of treatment. If a new soil is used, materials added, or sterilized, or compacted, a new curve must be obtained.

The tensiometer cup and sampling must be at equal depths in the soil. Additionally, the location of the tensiometer must be in a representative position. The indications obtained are not necessarily indicative of conditions 20 feet away or even across the bench.

Other instruments may be used in place of tensiometers. Equipment of the type shown in Figure 5 are not considered reliable above readings of 80 because air gets into the instrument rapidly. Electrical instruments such as Bouyoucos blocks are good when readings on a tensiometer exceed 100. But, it is our feeling that greenhouse soils which run dry enough to warrant the use of Bouyoucos blocks are much too dry (See Fig. 6). Other electrical instruments such as probes, etc. are best in dry soils and

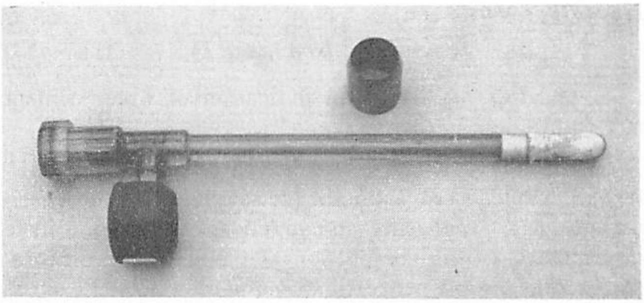

Figure 5: Tensiometer and core sampler. Filling cap on left, porous cup on right end. Cup must be placed at same depth in soil as core samples are taken.

Table 1: Tensiometer calibration data. The moisture content of 1-1-1, soil, sand and peat moss mixture at different soil moisture tensions. Depth of soil 7 inches.

Tensiometer reading[a]	Soil sample weights (g) Wet	Dry	Loss in weight (g)	Moisture content (%)
2	52	40	12	24
	56	42	14	28
	48	36	12	24
3	50	41	9	18
	48	38	10	20
	48	39	9	18
4	47	38	9	18
	52	41	11	22
	51	41	10	20
9	46	39	7	14
	46	38	8	16
	45	38	7	14
20	46	40	6	12
	45	39	6	12
	44	40	4	8
59	44	39	5	10
	44	39	5	10
	43	38	5	10
80	38	37	1	2
	45	41	4	8
	42	38	4	8

[a]Tensiometer reading: Multiply by 10 to determine approximate tension in cm water (i.e. 2x10 equals 20).

are also subject to variations resulting from changes in fertilizer level. Additions of fertilizer may require that the calibration procedure for electrical devices be repeated.

Essentially 3 items of equipment are needed for moisture determinations. Any competent machine shop should be able to make the core sampler (Fig. 1) for less than $5.00. A little ingenuity and modification can result in increased accuracy. Dietary scales are readily available, but one must specify that they be marked in grams (Catalog No. 3651, 500g capacity, $11.00, Will Corporation, Box 1050, Rochester 3, New York). Tensiometers similar to the type shown in Fig. 4 can be obtained from the Soil

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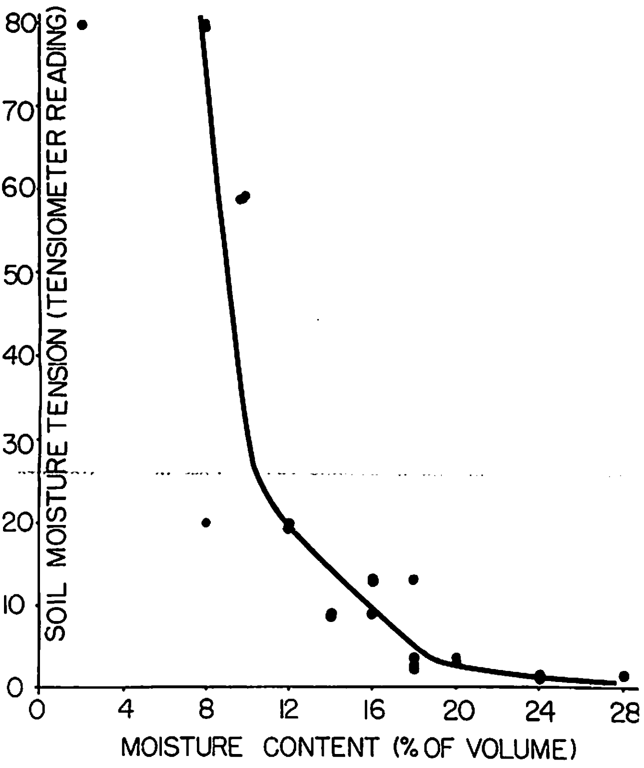

Figure 6: Tensiometer calibration curve for determining moisture content of a soil. Data from Table 1. Find Tensiometer reading on vertical axis, move horizontally until intersecting curved line, then drop straight down to horizontal axis. The figure obtained is the amount of water present, expressed as a per cent of the total soil volume. Warning: Do not confuse this with expressions of moisture content as a per cent of the soil's dry weight. Curve was drawn by inspection.

Moisture Equipment Company, 3005 de la Vina St., Santa Barbara, California. (Catalog No. 2700, 6 inch size, $9.75), or the Irrometer Company, P. O. Box 2424, Riverside, California (6 inch length between $20.00 to $35.00).

The use of calibration curves can be most instructive. The highest moisture content obtained (tensiometer reading of 2) was 28% (Fig. 6). This figure explains why Cornell in the past has always recommended heavy watering. In our soils, to maintain optimum moisture contents for maximum growth, it is necessary to water frequently. Also, when we add peat moss and sand to our local soil (1-1-1), the total pore space is usually between 60 and 70%. So, at moisture contents of 30%, we have fulfilled the requirements that 50% of the total pore space be filled with air. Also, at tensions in excess of 10 in this soil, moisture content is less than 15%, the lower limit for maximum plant growth. Returning to our original question: "How dry is your soil?"