NOTE

RAPID MEASUREMENT OF SOIL WATER
BY GRAVIMETRIC METHOD

Karimi, M.M., S.F. Mousavi and M. Heidarzadeh

College of Agriculture, Isfahan University of Technology, Isfahan, Iran.
(Received July 18, 1990)

ABSTRACT

Oven drying is used widely for soil water determination. Its main disadvantage is that it requires about 24 hr to obtain soil water percentage. To reduce the drying period, an experiment was conducted on 6 different textured soils. Samples were taken from six potometers, each filled with one soil type. Samples were weighed and kept at 110°C in an oven. The loss of weight was determined after 3, 6, 9, and 24 hr for each soil sample. The weight loss is assumed to be due to evaporation of water from soil. Linear and power regression equations were found for the weight loss after 3, 6 and 9 hr and that after 24 hr. It was concluded that the power regression with height correlation coefficients (r>0.95, P<0.01) can be used to estimate the water content of a soil sample if the amount of evaporated water is known after 6 or 9 hr. This approach will result in reduced drying time.

1- Assistant Professors and former Graduate Student, respectively.
نحیفات کشاورزی ایران
(1399) ۶۷-۶۸

اندازه‌گیری سریع رطوبت موجود در خاک به روش جابجایی سنجی

محمد مهدی کرمنی، سید فرهاد موسوی و مجید حیدرزاده

به ترتیب استاد باران و دانشجوی سابق کارشناسی ارشد، دانشکده کشاورزی، دانشگاه صنعتی اصفهان؛
اصفهان، ایران.

چکیده
روش جابجایی نمونه خاک با استفاده از آلون برای تعیین رطوبت خاک کاربرد و سمیعی دارد. اشکال اصلی
این روش که بیان روش و زنی نیز گویند، لوله‌ای بودن زمانی است که نمونه‌های خاک در آلون قرار
گرفته‌اند. برای کاهش این زمان، آزمایش‌هایی در ۲ نوع خاک با یک نوع مختلف از گرفته‌گیری در این
آزمایش از ۶ یا ۱ یونیتر (ظرف کاست گیاهی) که هر گیاه از یک نوع خاک پر شده بود نمونه برداری
شد. نمونه‌های خاک پس از نزدیکی در آلون با دما ۱۰۰ درجه سانتی‌گراد قرار گرفتند و مقدار آب
تیمی شده پس از ۲۴ یا ۹۰ و ۲۴ ساعت مشخص گردید. کاهش مقدار آب از خاک به عنوان آب
تیمی شده در نظر گرفته شد. حیص مشابه مقدار خاک بین رابطه این مقاورد آب از
دست رفته پس از ۱ و ۷ ساعت و آب تیمی شده پس از ۲۴ ساعت ارائه گردید. از این آزمایش
نتیجه‌گیری شد که رابطه نمایی دارای ضریب همبستگی (۰.۴) با بایو مقدار و رطوبت خاک با
استفاده از آب تیمی شده پس از ۷ یا ۹ ساعت قابل تخمین می‌باشد.

INTRODUCTION

Determination of soil water content by oven-drying method is widely
used on disturbed soil samples. In many situations, particularly in the field,
determination of soil water by this method involves at least a period of
24 hr from the time of sampling until the results become available. Several
methods have been proposed in the past to overcome the shortcomings of
the oven drying method (1, 2, 3, 4). The principal disadvantage of the
proposed methods is that they are fairly cumbersome and, therefore,
suitable for only a small number of samples (2). A method is proposed by Dahiya et al. (2) which involves recording the weight of a wide-mouthed glass flask filled with water after placing in it a soil sample of known weight. The weight of the flask, and the predetermined density of the soil and weight of the water filled flask are then used to determine moisture percentage of the soil sample. The disadvantages of this method are that it uses only 25 to 35 gr of soil, and air bubbles might not be expelled completely from soil.

The purpose of this study is to reduce the time required for soil water determination by gravimetric method.

**MATERIALS AND METHODS**

To decrease the 24 hr time needed in gravimetric method an experiment was conducted on six different textured soils of Isfahan, Iran. Some of the physical properties of the soils are shown in Table 1. An electric oven (Heraeus, DVE), an electric balance (Metler PL 1200) with an accuracy of 0.01 gram, and 25 sampling cans (10 cm diameter and 4.5 cm long) were used in this experiment.

Table 1. Some of the physical properties of the soils used in this study.

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Sampling depth (cm)</th>
<th>Field capacity (%) by wt.</th>
<th>Permanent wilting point (%)</th>
<th>Organic matter (%)</th>
<th>2.0-0.05 (mm)</th>
<th>0.05-0.002 (mm)</th>
<th>&lt;0.002 (mm)</th>
<th>Soil texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20</td>
<td>30.7</td>
<td>13.9</td>
<td>2.005</td>
<td>19</td>
<td>37</td>
<td>44</td>
<td>Clay</td>
</tr>
<tr>
<td>2</td>
<td>0.20</td>
<td>24.6</td>
<td>13.5</td>
<td>1.182</td>
<td>15</td>
<td>55</td>
<td>30</td>
<td>Silty clay loam</td>
</tr>
<tr>
<td>3</td>
<td>0.20</td>
<td>23.8</td>
<td>13.1</td>
<td>1.743</td>
<td>29</td>
<td>43</td>
<td>28</td>
<td>Clay loam</td>
</tr>
<tr>
<td>4</td>
<td>0.20</td>
<td>15.0</td>
<td>10.8</td>
<td>0.581</td>
<td>47</td>
<td>31</td>
<td>22</td>
<td>Loam</td>
</tr>
<tr>
<td>5</td>
<td>0.20</td>
<td>22.8</td>
<td>6.5</td>
<td>0.582</td>
<td>50</td>
<td>24</td>
<td>26</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td>6</td>
<td>0.20</td>
<td>6.8</td>
<td>3.5</td>
<td>1.452</td>
<td>89</td>
<td>3</td>
<td>8</td>
<td>Sandy</td>
</tr>
</tbody>
</table>
Six potometers (50 cm diameter and 90 cm depth) were buried in the field so that their tops were at the same level as the ground surface. Each potometer was filled with one type of soil. To cover a broad range of soil moisture, each potometer was saturated and five soil samples were taken from the surface horizon (0-20 cm) with a hand auger every day, for five consecutive days. The first samples (five replicates) were taken one day after the saturation. The soil samples were placed in the cans and brought to the laboratory. The oven temperature was brought to 110°C. Soil cans were weighed and then placed in the oven. The samples were then weighed after 3, 6, 9 and 24 hr of drying. The difference between the weights (at the beginning and end of each time period) shows the weight of water evaporated during the elapsed time. The weight of evaporated water was used to relate percent water contents after 3, 6, and 9 hr with that at 24 hr. The amount of evaporated water was also measured after 12, 15, 18 and 21 hr for one sample of each soil.

RESULTS AND DISCUSSION

In Fig.1 the percent water content is shown versus time of oven drying for different soils. This figure shows that the sandy soil (No.6) reaches an equilibrium after about 9 hr drying time, but the clay soil (No. 1) loses water even after 24 hrs. Other textures are intermediate.

Table 2 shows the linear regression equations developed between the weight of water evaporated after 3, 6 and 9 hr and the water evaporated after 24 hr of oven drying. The correlation coefficients (r) of 3 and 24 hr of the soils No. 1 to 5 are very good. With increasing the time of oven drying, the coefficients increase. In soil No.6, which is a sandy soil, the water content after 24 hr could be estimated after only 3 hr of oven drying.
Fig.1. Percent moisture content versus time of oven-drying the different soils.
Table 2. Linear regression equations between the weight of water evaporated after 3, 6 and 9 hr and 24 hr of oven drying.

<table>
<thead>
<tr>
<th>Soil</th>
<th>Texture</th>
<th>3 and 24 hr</th>
<th>6 and 24 hr</th>
<th>9 and 24 hr</th>
<th>3 and 24 hr</th>
<th>6 and 24 hr</th>
<th>9 and 24 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td></td>
<td>$W_{24} = A + BW_3$</td>
<td>$W_{24} = A + BW_6$</td>
<td>$W_{24} = A + BW_9$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>C</td>
<td>$W_{24} = 25.4 + 5.5W_3$</td>
<td>$W_{24} = 23.9 + 2.9W_6$</td>
<td>$W_{24} = 14.4 + 1.8W_9$</td>
<td>0.77</td>
<td>0.97</td>
<td>0.98</td>
</tr>
<tr>
<td>2</td>
<td>Si.C.L.</td>
<td>$W_{24} = 15.7 + 4.4W_3$</td>
<td>$W_{24} = 13.5 + 2.3W_6$</td>
<td>$W_{24} = 5.5 + 1.5W_9$</td>
<td>0.71</td>
<td>0.94</td>
<td>0.98</td>
</tr>
<tr>
<td>3</td>
<td>C.L.</td>
<td>$W_{24} = 6.4 + 3.5W_3$</td>
<td>$W_{24} = 11.1 + 2.1W_6$</td>
<td>$W_{24} = 4.5 + 1.3W_9$</td>
<td>0.74</td>
<td>0.96</td>
<td>0.99</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
<td>$W_{24} = 15.3 + 4.2W_3$</td>
<td>$W_{24} = 12.0 + 2.1W_6$</td>
<td>$W_{24} = 5.3 + 1.4W_9$</td>
<td>0.83</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>5</td>
<td>S.C.L.</td>
<td>$W_{24} = 4.1 + 3.2W_3$</td>
<td>$W_{24} = 5.2 + 1.9W_6$</td>
<td>$W_{24} = 1.1 + 1.3W_9$</td>
<td>0.70</td>
<td>0.96</td>
<td>0.98</td>
</tr>
<tr>
<td>6</td>
<td>S</td>
<td>$W_{24} = 1.7 + 1.5W_3$</td>
<td>$W_{24} = 0.7 + 1.0W_6$</td>
<td>$W_{24} = 0.5 + 1.0W_9$</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Sell No.</td>
<td>3 and 24 hr</td>
<td>6 and 24 hr</td>
<td>9 and 36 hr</td>
<td>12 and 24 hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
<td>--------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Three power regression equations between the weight of water evaporated after 3, 6, and 9 hr of oven drying.
Table 4. Mean, standard deviation and the estimated amount of water evaporated after different times for different soils.

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Texture</th>
<th>X_11a</th>
<th>SD_11</th>
<th>X_12</th>
<th>SD</th>
<th>X_13</th>
<th>SD</th>
<th>X_14</th>
<th>SD</th>
<th>X_15</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>12.2</td>
<td>1.9</td>
<td>40.8</td>
<td>4.5</td>
<td>41.7</td>
<td>7.5</td>
<td>41.8</td>
<td>4.8</td>
<td>42.5</td>
<td>3.8</td>
</tr>
<tr>
<td>2</td>
<td>S.C.L.</td>
<td>10.6</td>
<td>1.5</td>
<td>31.3</td>
<td>3.8</td>
<td>31.5</td>
<td>6.2</td>
<td>31.7</td>
<td>3.2</td>
<td>32.0</td>
<td>2.9</td>
</tr>
<tr>
<td>3</td>
<td>C.L.</td>
<td>12.0</td>
<td>2.0</td>
<td>35.0</td>
<td>4.3</td>
<td>35.1</td>
<td>7.1</td>
<td>35.4</td>
<td>3.5</td>
<td>35.4</td>
<td>8.6</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
<td>12.8</td>
<td>2.9</td>
<td>36.4</td>
<td>6.8</td>
<td>37.4</td>
<td>10.4</td>
<td>37.7</td>
<td>14.8</td>
<td>36.3</td>
<td>14.8</td>
</tr>
<tr>
<td>5</td>
<td>S.C.L.</td>
<td>12.9</td>
<td>2.5</td>
<td>36.0</td>
<td>5.8</td>
<td>36.7</td>
<td>6.9</td>
<td>36.9</td>
<td>6.9</td>
<td>37.0</td>
<td>11.2</td>
</tr>
<tr>
<td>6</td>
<td>S</td>
<td>12.0</td>
<td>3.9</td>
<td>18.6</td>
<td>6.0</td>
<td>18.7</td>
<td>6.0</td>
<td>18.7</td>
<td>6.1</td>
<td>18.7</td>
<td>6.1</td>
</tr>
</tbody>
</table>

† X_11a = measured average amount (grams) of water evaporated.

§ SD = Standard deviation for 25 soil samples.

§§ X_15 = estimated average amount (grams) of water evaporated after 24 hr, using equations of Table 3.
Table 3 shows power regression relations between the weight of water evaporated after 3, 6 and 9 hr and that after 24 hr. Comparison of the correlation coefficients of Table 3 with those of Table 2 shows, in most cases, little improvement over Table 2. The amount of water which will evaporate after 24 hr is estimated (Table 4) using Table 3. For example, for soil No.1 the mean measured amount of water lost after 24 hr is 42.5 gr. The estimated values are 40.8, 41.7 and 41.8 gr after 3, 6 and 9 hr of oven drying, respectively. The difference between the actual and estimated values are, then, 4, 1.8 and 1.6 percent, respectively. For soil No.6, the estimated values are closer to the actual value. The maximum difference in this table is that of soil No.4, which is 5.0 percent.

CONCLUSION

It was concluded that power regression equations could be developed and used to estimate the soil water content, after 24 hr if the value at 6 or 9 hr is known. For sandy soils, only 3 hr of oven drying is enough to estimate the water content after 24 hr. Since soil texture, density and organic matter affect the amount of water that can be evaporated from the soil, thus it is necessary to obtain regression equation for every texture.

LITERATURE CITED