SOIL PHYSICS
LABORATORY MANUAL

BY

J. G. MOSIER, B.S.
PROFESSOR OF SOIL PHYSICS, UNIVERSITY OF ILLINOIS

AND

A. F. GUSTAFSON, M.S.
ASSOCIATE IN SOIL PHYSICS, UNIVERSITY OF ILLINOIS

GINN AND COMPANY
BOSTON • NEW YORK • CHICAGO • LONDON
PREFACE

These practices are the result of ten years' experience in teaching soil physics, and are designed for one semester's work, during which it is hoped to give the student a knowledge of the principles that underlie many common agricultural operations.

In a number of practices students may work together in groups, not so large, however, but that each one may have a distinct problem to work out in each practice. This plan will enable the class to complete the work in one semester, which otherwise might not be possible.

Questions are asked and references given to enable the student to get the greatest amount of information possible out of each practice.

An appendix of additional practices is added for students who wish to pursue the subject further.

THE AUTHORS

University of Illinois, College of Agriculture
Urbana, Illinois
# CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Apparatus for Each Student</td>
<td>v</td>
</tr>
<tr>
<td>Weights and Measures</td>
<td>vi</td>
</tr>
<tr>
<td>Stock Soils and their Preparation</td>
<td>1</td>
</tr>
<tr>
<td>Collecting Soil Samples</td>
<td>1</td>
</tr>
<tr>
<td>Determination of Capillary Moisture in Soils</td>
<td>4</td>
</tr>
<tr>
<td>Determination of Hygroscopic Moisture in Soils</td>
<td>6</td>
</tr>
<tr>
<td>Effect of Drainage on Temperature of a Soil</td>
<td>8</td>
</tr>
<tr>
<td>Effect of Color on Temperature of a Soil</td>
<td>10</td>
</tr>
<tr>
<td>Determination of Total Moisture in the Same Soil under Different Conditions</td>
<td>12</td>
</tr>
<tr>
<td>Determination of the Variation in the Hygroscopic Moisture of Soils</td>
<td>14</td>
</tr>
<tr>
<td>Floculating Effect of Lime</td>
<td>16</td>
</tr>
<tr>
<td>Determination of the Effect of Lime on Plastic Soils</td>
<td>18</td>
</tr>
<tr>
<td>Testing the Tenacity of Moist Soils</td>
<td>20</td>
</tr>
<tr>
<td>Determination of Shrinkage in Soils</td>
<td>22</td>
</tr>
<tr>
<td>Determination of the Apparent Specific Gravity of Soils</td>
<td>23</td>
</tr>
<tr>
<td>Determination of Apparent Specific Gravity of Surface Soil under Field Conditions</td>
<td>26</td>
</tr>
<tr>
<td>Determination of Real Specific Gravity of Soils</td>
<td>28</td>
</tr>
<tr>
<td>Determination of Porosity (First Method)</td>
<td>30</td>
</tr>
<tr>
<td>Determination of Porosity (Second Method)</td>
<td>32</td>
</tr>
<tr>
<td>Determination of Loss on Ignition</td>
<td>34</td>
</tr>
<tr>
<td>Determination of Humus in Soils</td>
<td>36</td>
</tr>
<tr>
<td>Determination of Conductivity of Heat in Soils</td>
<td>38</td>
</tr>
<tr>
<td>Determination of Specific Heat of Soils</td>
<td>40</td>
</tr>
<tr>
<td>The Power of Loose Soils to retain Capillary Water</td>
<td>42</td>
</tr>
<tr>
<td>The Power of Compact Soils to retain Capillary Water</td>
<td>44</td>
</tr>
<tr>
<td>Effect of Organic Matter on Retention of Capillary Water</td>
<td>46</td>
</tr>
<tr>
<td>Determination of the Rate of Percolation of Air through Soils</td>
<td>48</td>
</tr>
<tr>
<td>Determination of the Rate of Percolation of Water through Soils</td>
<td>50</td>
</tr>
<tr>
<td>Effect of a Layer of Organic Matter on Rise of Capillary Water</td>
<td>52</td>
</tr>
<tr>
<td>A Study of the Capillary Power of Different Grades of Sand</td>
<td>54</td>
</tr>
<tr>
<td>A Study of the Capillary Power of Soils</td>
<td>56</td>
</tr>
</tbody>
</table>
Effect of Organic Matter on Rise of Capillary Water . . . . . . 58
Effect of Varied Quantities of Salts in Solution on Rapidity and
Height of Rise of Capillary Water . . . . . . . . . . . . . . . . . . . . 60
Determination of Per Cent of Capillary Water at Different Heights
above the Water Table . . . . . . . . . . . . . . . . . . . . . . . . . . . 62
A Study of the Physical Composition of Soils . . . . . . . . . . . . . 64
Standardization of the Eyepiece Micrometer . . . . . . . . . . . . . 65
Mechanical Analysis . . . . . . . . . . . . . . . . . . . . . . . . . . . . 68
Determination of the Effect of Cultivation and Mulches upon Tem-
perature and Moisture Content . . . . . . . . . . . . . . . . . . . . . . 69
Effect of Soluble Salts on Retention of Capillary Water . . . . . . . 70
Determination of Coefficient of Evaporation . . . . . . . . . . . . . 71
APPARATUS FOR EACH STUDENT

1 Asbestos mat, 10 cm. square
4 Beakers, assorted sizes
1 Blue pencil, wax for marking on glass
1 Brush, camel’s-hair
1 Bunsen burner
1 Capsule, horn, 10 cm. long
1 Cheesecloth, one yard
4 Corks, same size as No. 8 rubber stopper
6 Crucibles, 25 cc.
6 Crucibles, 50 cc.
1 Desiccator, 15 cm. in diameter
4 Erlenmeyer flasks, 250 to 500 cc.
1 Forceps, brass, 10 cm. long
4 Funnel, 10 cm. in diameter
1 Graduated cylinder, 100 cc.
1 Box of gummed labels
6 Jars, Mason’s pint
1 Vial of litmus paper, blue
1 Box of matches
1 Mortar and pestle, 12.5 cm. in diameter

1 Ring stand, small, medium, and large rings
1 Rubber policeman on glass’ rod 20–22 cm. long
4 Rubber stoppers, No. 8
1 Ruler, 30 cm., 12 inch
4 Shaker bottles, 375 to 400 cc.
12 Soil pans, 10 cm. square, 5 cm. deep
2 Soil pans, 10 × 22 cm., 5 cm. deep
1 Spatula, 15 cm. blade
1 Spoon, horn, 10 cm. long
2 Test tubes
1 Tongs, crucible, 20 to 25 cm. long
2 Towels
1 Triangle, pipetstem flanged, medium
1 Wash bottle, 500 to 750 cc.
5 Watch glasses 56 mm., 2½ inches in diameter
4 Watch glasses 106 mm., 4½ inches in diameter
8 Weighing bottles, 30 mm. in height and diameter
WEIGHTS AND MEASURES

1 Meter = 39.37 inches = 3.28 feet
1 Centimeter = .3937 inches
1 Kilogram = 2.2 pounds avoirdupois
1 Liter = \[
\begin{cases}
1.056 \text{ quarts} \\
61.02 \text{ cubic inches}
\end{cases}
\]
1 Inch = \[
\begin{cases}
25.40 \text{ millimeters} \\
2.5399 \text{ centimeters}
\end{cases}
\]
1 Pound = 453.59 grams
1 Cubic foot of water weighs 62.42 pounds
1 Square foot inch of water weighs 5.201 pounds
1 Acre inch of water = 226,000 pounds (approximately)
1 Acre = 43,560 square feet
Circumference of a circle = \(2 \pi r\) or \(\pi D\)
Area of circle = \(\pi r^2\)
Area of a sphere = \(4 \pi r^2\) or \(\pi D^2\)
Volume of a sphere = \(\frac{4}{3} \pi r^3\) or \(\frac{1}{6} \pi D^3\)
Volume of a cylinder = \(\pi r^2h\); \(h = \) altitude
SOIL PHYSICS
LABORATORY MANUAL

STOCK SOILS AND THEIR PREPARATION

The soils commonly used are (1) a sand or sandy loam, (2) a gray silt or gray silt loam, (3) a brown silt loam, (4) a clay or clay loam, and (5) peat. Any other soils may be used. The selection of soils for class use should depend largely on the locality. The prevailing types in the vicinity should be used. These soils should be thoroughly air-dried, and ground sufficiently fine to pass through a 2-mm. sieve.

COLLECTING SOIL SAMPLES

In collecting samples of soil a one and one-half or a two-inch auger with an extension, making it 40 inches long, should be used. Select the place for sampling and remove any vegetation. Collect the surface soil to a depth of approximately 6\frac{2}{3} inches, or to the plow line. Enlarge the hole by reaming out with the auger so that the subsurface soil may be removed without coming in contact with the surface soil. Take the subsurface sample to the depth of 20 inches. This gives the subsurface 13\frac{1}{3} inches, or twice that of the surface. It may be desirable in some cases to take the subsurface to the natural subsoil line, as indicated by the change in color and physical composition, usually from 15 to 20 inches in depth. Enlarge and clean out the hole as before and collect the subsoil to a depth of 46 inches. It may be convenient to divide the subsoil into two equal parts of 10 inches each. In collecting samples for moisture determinations, expose the soil to the air as little as possible before putting in jars.
Fig. 1. Soil Samplers

A, one-inch field auger; B, one and one-half to two-inch sampling auger; C, extension rods; D, King's soil-sampling tube; E, hammer for forcing D into soil.
PRACTICE I

DETERMINATION OF CAPILLARY MOISTURE IN SOILS

The moisture content in these exercises will always be expressed as per cent of the water-free soil.

Use the soil collected according to method given on a previous page and make the determinations in duplicate for surface, subsurface, and subsoil.

Record all data on the opposite page.

Weigh carefully six soil pans. Place in each pan 200 g. of the soil and weigh quickly to avoid loss of moisture by evaporation. Dry at room temperature for 72 hours, after which weigh at intervals of 24 hours until a practically constant weight is obtained. The loss in weight is the capillary moisture. Express results in grams, and after completing the next exercise express results in per cent of water-free soil.

Use these air-dry soils for Practice II.

REFERENCES.