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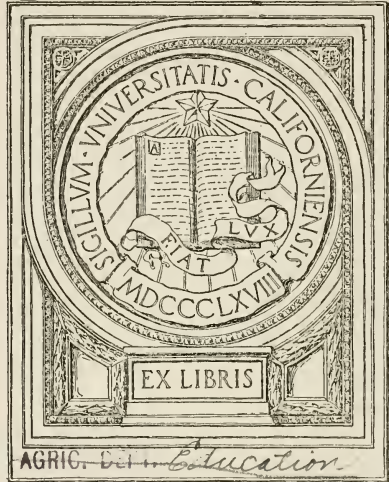


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SOILS LABORATORY
MANUAL AND NOTE BOOK
EASTMAN AND DAVIS

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SOILS LABORATORY MANUAL AND NOTE BOOK

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21 ILLUSTRATIONS IN THE TEXT



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FOREWORD

This Manual is intended for the use of students studying soils, whether they be in high schools, agricultural schools, or in colleges. It is believed that the experimental method of studying soils serves to fix in mind their characteristics and the principles concerning their best management.

The equipment to be used in performing these exercises is simple and inexpensive. In a number of exercises suggestions are given for using tin cans instead of regular soil tubes, and other similar substitutions are possible.

Acknowledgments are due Ginn and Company, Boston, for the use of certain exercises (4, 17, 25, and 26), somewhat adapted for use here from "Soil Physics Laboratory Manual," by Mosier and Gustafson; to Prof. E. O. Fippin of Cornell University Department of Soil Technology, for the use of exercises 3, 27, and 29, adapted from his "Laboratory Guide in Agricultural Soils," used by Cornell students in typewritten form. Many of the publications mentioned in the reference list have been drawn upon freely for aid. Obligations are here expressed for the suggestions received from many books and papers on the subject.

THE AUTHORS

April, 1915.

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SOILS LABORATORY MANUAL AND NOTE BOOK

INSTRUCTIONS CONCERNING LABORATORY WORK IN SOILS

1. Students will be expected to be in the laboratory and ready for work at the appointed time for the period to begin.

2. A schedule will be found in the laboratory indicating the exercise for each student or group of students to perform for each period.

3. Students will be held responsible for the breakage of all apparatus.

4. Experiments should be carefully labelled with the owner's name and set away before leaving the laboratory.

5. Some of the experiments require a small amount of daily attention. This must be given in all cases and credit will be allowed.

6. Experiments should be completed promptly and when finished the apparatus should be cleaned as quickly as possible.

7. Each experiment must be written up promptly after the time that it is completed.

8. All questions should be clearly and fully answered in the note book. The report for two experiments should never be confused—let each be complete in itself. Note books will be graded on correctness of the results of the experiments, the way in which the experiment is written up, and the neatness of the work.

9. Before commencing an exercise, read over the object and directions very carefully. Be sure that you understand clearly what is to be done before you commence work.

10. The following list of reference books, along with the text-books in use by the students should be consulted in writing up the results of the exercises. If possible, they should be on a special shelf in the library.

(12) INSTRUCTIONS CONCERNING LABORATORY WORK IN SOILS (CON.)

REFERENCE BOOKS

Soils	Fletcher.
The Soil	Hall.
Agriculture, Vol. I	Brooks.
Soils	Burkett.
Soils	Hilgard.
Physics of Agriculture	King.
Soil Management	King.
Farmers of Forty Centuries	King.
Rocks, Rock Weathering and Soil Formation	Merrill.
Rocks and Soils	Stockbridge.
Physical Properties of Soil	Warington.
The Fertility of the Land	Roberts.
Irrigation Farming	Wilcox.
Soil Culture Manual	Campbell.
Dry Farming	Widtsoe.
Engineering for Land Drainage	Elliot.
Fertilizers and Crops	VanSlyke.
Soil Fertility and Permanent Agriculture	Hopkins.
Soils	Lyon and Fippin.
Bacteria in Relation to Country Life	Lipman.
Soils of the United States	Bulletin 96, U. S. Bureau of Soils.

“If a man can write a better book, preach a better sermon, or make a better mousetrap than his neighbor, though he build his house in the woods, the world will make a beaten track to his door.”

EXERCISE 1

(13)

FIELD STUDY OF PROCESSES OF SOIL FORMATION

PLAN

- A. Examine a sample of soil and name all of the materials of which it is composed. How much organic matter is there in this soil? Show clearly how this organic matter has been formed. Compare its age with that of the inorganic matter.
- B. Study the work of the various soil-forming agencies which you find and discuss clearly and fully the part which each of these different actions plays in the formation of the soil.
1. *Moving Ice*.—Look for deep scratches on the solid rock which forms a part of the earth's crust. What is a glacier? How did it act in the formation of soils in New York?
 2. *Moving Water*.—Examine the banks of a brook and find where the land has been built up on one side and cut away on another. Explain the smoothness and roundness of the stones and other material in the bed of the brook. What effect has size upon the way in which the material is deposited? Walk along the base of a steep hillside and note the effect of water in bringing down soil. Is this action beneficial or injurious? Why? How does a water-formed soil differ from that formed by ice? How does the water grade the soil according to the size of particles?
 3. *Chemical Action of Air and Water; Weathering*.—Why do some rocks seem to crumble easier than others? Examine an old stone wall. Do the rocks rest as securely as they did when they were first laid? What has caused certain rocks to crack open?
 4. *Changes in Temperature*.—Show clearly how the forces of heat and cold may cause rocks to crumble.
 5. *Action of Living Plants and Animals*.—Look for lichens growing upon rocks. What is the condition of the rock underneath and how do these plants act as soil builders? Look for the roots of trees growing between rocks. Discuss. Do you find small roots of plants between layers of rock? Look for the work of earthworms, also other animals.
 6. *Effects of Organic Matter*.—Examine a piece of iron which has been in a manure heap or a pile of decaying organic matter. Explain the action. Examine a swamp and note how it has filled up. How is muck formed?
 7. *Winds*.—Find some soil transported by winds. Is such action beneficial or injurious at the present time? Give two different kinds of soil which are formed by the wind and state their location, composition, and agricultural value.
- C. Examine surface soil and subsoil. How do they differ? Describe each carefully.
- D. If possible, examine the soil of an old pasture which has never been plowed. Is the dark-colored surface soil as deep here as on land which has been cultivated for several years? Why?

(14)

EXERCISE 1 (CONTINUED)

NOTES AND REPORT OF THE STUDY

NOTES AND REPORT OF THE STUDY (*Continued*)

(16)

EXERCISE 2

TAKING SOIL SAMPLES

PURPOSE.—To show students several methods of taking true samples of field soils.

PLAN

1. Dig a hole with a spade to the depth of one foot (more or less if desired). Place a folded newspaper or piece of oilcloth to form a pocket in the bottom of the hole. Then with the spade shave off a uniform slice of soil from top to bottom of one side of the hole. This slice should be caught in the paper as it crumbles and should be saved as the sample. If it is desired to test the soil for moisture content, sample should be

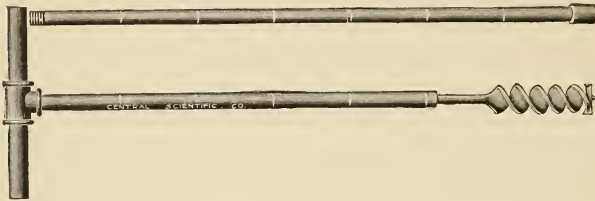


FIG. 1.—Soil auger for obtaining soil samples at different depths. The bit should be about $1\frac{1}{2}$ inches in diameter. This auger may be had in short sections for ease in carrying when travelling considerable distances.

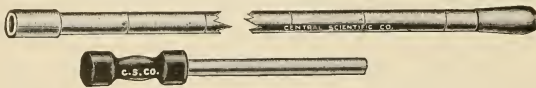


FIG. 2.—King type of soil sampling machine. The opening just back of the steel cutting edge is smaller inside and the cylinder larger than the rest of the tube. This makes the tube more easily removed from the soil, and the core of soil is removed from the tube by inverting it. The steel shown at the left is placed in the tube and may receive the blows of a hammer.

placed promptly in a wide-mouthed bottle or jar. It should be sealed to prevent the escape of moisture.

2. A common way of taking soil samples where great depth is necessary is to use a common auger, having an extra long shaft—the bit may be from one to two inches in diameter. Special soil augers are made for this purpose (Fig. 1).
3. Soil sampling cylinders are also used for taking field samples (Fig. 2). They are made of heavy iron or steel tubing, sharpened at one end. Just back of the sharp edge the opening is slightly constricted to compress the core of soil so that it may be more easily removed from the tube. The tube may be driven into the soil by the use of a sledge hammer or axe.

QUESTIONS

1. For what purpose should field samples ever be taken by farmers?
2. Can you devise a method of taking field samples easily where the soil is stony or gravelly?
3. What may be learned regarding the character of soil while the sample is being taken?

NOTE.—All samples should be properly labelled to show from where they were taken, when, and to what depth.

4. Why is it necessary to take samples from the subsoil as well as the surface soil?
5. Does soil analysis furnish complete knowledge as to the productiveness of the soil? Why?

EXERCISE 3

STUDY OF SOIL GRAINS

PURPOSE.—To become familiar with the composition, color, size and the individual particles in a soil and to see clearly the difference between various types of soils.

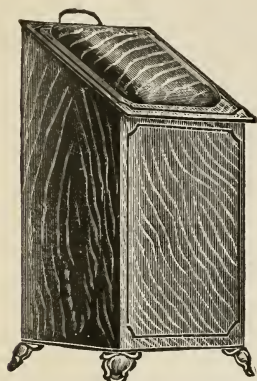


FIG. 3.—A suitable form of bin for storing soils in school and college laboratories.

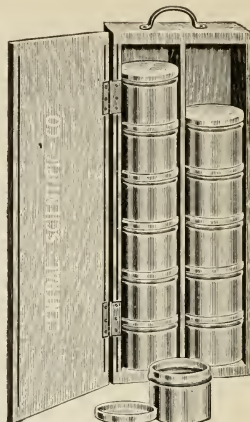


FIG. 4.—Pint tin cans are suitable for use in taking soil samples. The moisture may be held by tightly fitting covers.

PLAN *

1. Obtain from the field or from soil supplies in the laboratory, samples of the following soils: sand, sandy loam, loam, clay and muck (Figs. 3 and 4).
2. Examine these soils with reference to the following points and record results in the table.
When dry: (a) color, (b) odor, (c) fineness or texture—coarse, medium or fine.
When moist: (a) color, (b) odor, (c) crumbly or plastic.

*Adapted from Department of Soil Technology, Cornell University.

Physical Properties of Soils

Soil	Color		Odor		Texture	Condition
	Dry	Wet	Dry	Wet	Dry	Wet
Sand.....						
Sandy loam						
Loam.....						
Clay.....						
Muck.....						

3. Examine under the high or low power microscope, samples of fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt, and clay, sandy loam and muck. Make drawings of each showing how they differ in shape and relative size.

QUESTIONS

1. How do the particles in each of the samples differ in color?
2. Name the first seven according to relative size, stating their diameter in inches.
3. Compare them with the sample of sandy loam.
4. How does the muck differ from the others in texture and general appearance?

(20)

EXERCISE 4

COMPOSITION OF SOILS

PURPOSE.—To determine the composition of soils by the sedimentation method.

PLAN *

For this work, samples of at least three widely different soil types common in the locality should be examined.

1. Place about 10 cc. of the soil to be studied in a dry 100 cc. glass graduate.
2. Fill two-thirds full with water and shake vigorously at intervals for ten minutes. Allow to stand until the soil has settled. Then estimate as closely as possible the proportion of the different grades of gravel, sand, silt and clay which are present.

Repeat this operation with the other samples.

Composition of the Soil

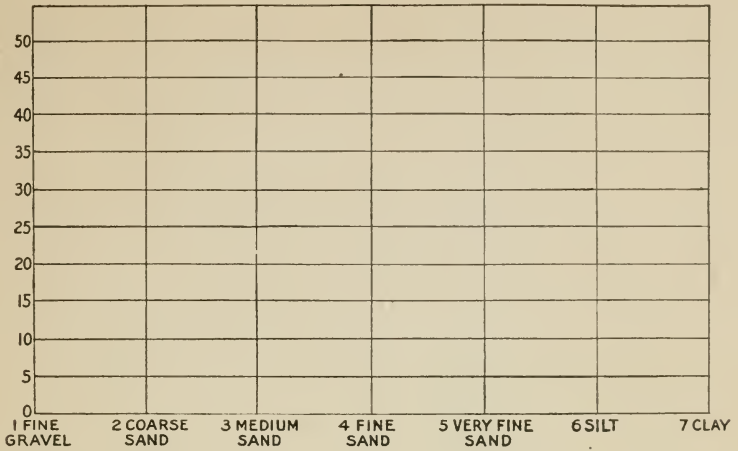
Kind of soil	Organic matter	Gravel	Sand	Silt	Clay

3. Consult the soil survey bulletin (as directed by the instructor) for the results of a mechanical analysis of these soils. Then plot curves showing graphically their relative texture and the proportionate amount of the different groups of separates. Use the chart on page 78 of "Soils" by Lyon and Fippin as a guide.

QUESTIONS

1. What is a mechanical analysis of a soil?
2. How does it differ from a chemical analysis?
3. How do the mechanical analyses of soils made by the U. S. Department of Agriculture differ from the results of above exercise?

*Adapted from "Laboratory Manual for Soil Physics"—Mosier.



Grade.....

Date.....

(22)

EXERCISE 5

SOIL CLASSIFICATION

PURPOSE.—To enable the student to become familiar with a few common soil series and types.

PLAN

Describe each area of soil studied according to the following outline:

	1st area	2nd area	3rd area
Climate of the section.....			
Method of formation.....			
Source of material.....			
Topography.....			
Altitude.....			
Color of surface soil.....			
Color of subsoil.....			
Drainage.....			
Organic matter.....			
Lime content.....			
Rock: amount, shape, kind			
Arrangement of matter...			
Stratified.....			
Structure.....			
Texture.....			
Complete analysis.....			
Remarks.....			
Name of soil.....			

EXERCISE 6

(23)

VOLUME-WEIGHT OR APPARENT SPECIFIC GRAVITY

PURPOSE.—To compare the weight of a tube of soil with the weight of a tube of water filled to exactly the same height. This result will give the apparent specific gravity of the soil or the weight of soil compared with an equal volume of water. If desired the sample may be taken with a tube shown in Fig. 5.

PLAN

1. Take one of the special tubes which has the opening at the bottom plugged with a cork stopper and from which the brass strainer has been removed; or use a tube with solid bottom as in Fig. 6. (Schools not equipped with soil tubes may use tin cans.)
2. Be sure that the tube is dry. Then weigh it carefully on the balances.
3. Fill the tube with sand to within one inch of the top, pouring it in loosely. Weigh carefully on the balances.
4. Empty the soil back into the right bin and fill the tube again, but this time compact the soil in the compacting machine. If no compacting machine is available, pack the soil by dropping the tube from the height of five inches five times upon a book.
5. Repeat this operation for all of the five soils, recording the weights in the table.
6. Finally fill the tube with water to exactly one inch from the top and weigh carefully.
7. If the real specific gravity of these soils is known secure them from the instructor and then compute the porosity of each. See (3) below.
8. The following formulas may be followed in working out the calculations:

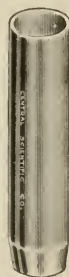


FIG. 5.—Soil sampling tube for taking a sample of surface soil in an undisturbed condition—useful in determining the volume weight of soil in its field condition.

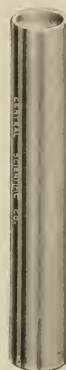


FIG. 6.—Twelve-inch tube with solid bottom, for use in determining volume-weight and pore space.

$$\text{Volume-weight} = \text{Weight of a tube full of soil} \quad (1)$$

$$\text{Apparent Specific Gravity} = \frac{\text{Weight of Soil}}{\text{Weight of Water}} \quad (2)$$

$$P = 100 - \left(\frac{\text{Ap. Sp. Gr.}}{\text{Ab. Sp. Gr.}} \times 100 \right) \quad (3)$$

Apparent Specific Gravity

Soil	Wt. soil + tube		Wt. tube		Wt. soil		Ap. sp. gr.		Porosity	
	Com- pact	Loose	Com- pact	Loose	Com- pact	Loose	Com- pact	Loose	Com- pact	Loose
Sand.....										
Sandy loam....										
Loam.....										
Clay.....										
Muck.....										

Weight of equal volume of water _____

QUESTIONS

1. From the result secured calculate the weight per cubic foot of each of the soils.
2. Finally calculate the weight per acre foot.
3. What is meant by the volume-weight of soil?
4. Give a definition of specific gravity.
5. What is the difference between apparent specific gravity and real specific gravity?
6. What is meant by porosity?
7. What is the porosity of the average soil?
8. State clearly the necessity for pore space in soil.
9. What influence has (a) organic matter, (b) texture, (c) structure upon the porosity of a soil? Upon the weight of a soil? Why?
10. Which is heavier, a coarse or a fine soil? Why?
11. What does this exercise show concerning the comparative weight and apparent specific gravity of land recently plowed and land unplowed?

(26)

EXERCISE 7

TRUE SPECIFIC GRAVITY

PURPOSE.—To determine the real specific gravity of any sample of soil.

PLAN

1. Fill a specific gravity bottle with distilled water and weigh it (Fig. 7).
Pour out part of it and add ten grams of oven-dry soil. Heat the content

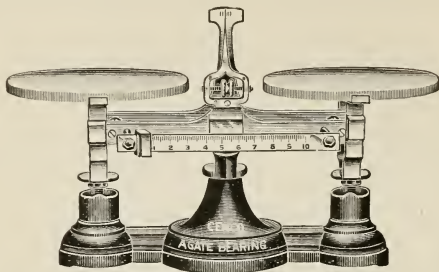


FIG. 7.—An accurate scale with agate bearing is a valuable part of the equipment for studying agricultural soils.

slightly to drive out any air adhering to the soil. Now refill the bottle with distilled water and weigh again.

2. Divide the loss in weight of water into the weight of soil to find the specific gravity. Record the results in the following table.

Specific Gravity of Soil Grains

Kind of soil	Wt. bottle and water	Soil, bottle water	Water displaced	Specific gravity

NOTE.—Students should, if possible, compare the real specific gravity of sand, clay, humus soil and others.

QUESTIONS

1. What precaution should you take in the careful performance of this exercise?
2. Why are specific gravity bottles provided with glass stoppers having small openings?

3. Give a definition of true specific gravity.
4. Of what value to the farmer is a knowledge of the specific gravity of his soil? Would it indicate anything regarding the amount of humus or the amount of sand?
5. Name the four principal minerals from which soil has been derived. State and discuss their specific gravities.
6. What is the average specific gravity of soil grains?
7. Look up the specific gravities of sand, silt, and clay and discuss them.

(28)

EXERCISE 8

HEAVY AND LIGHT SOILS

PURPOSE.—To find why certain soils are called “heavy” and others “light.”

PLAN

1. Fill a soil tube or tin can with dry sand, pack well, refill, strike off with straight edge and weigh. Empty the vessel and weigh it while empty. Record results in the following table.
2. In like manner determine the weights of the same volume of several other soils, such as black humus soil, heavy clay, and medium loam.

Results

Kind of soil	Wt. tube	Wt. soil and tube	Wt. soil only

QUESTIONS

1. Arrange the soils in the order of their actual weights.
2. Why does the farmer call clay soils heavy soils?
3. Are the so-called heavy soils really as heavy as sandy soils?
4. Why are sandy soils spoken of as light soils?
5. Would humus added to heavy soils make them plow easily?
6. What effect would sand have on clay soils in this regard?

(30)

EXERCISE 9

EFFECTS OF ORGANIC MATTER

PURPOSE.—To study the effects of organic matter in soils.

PLAN

1. Secure directions from the instructor in charge as to where the samples of soil shall be taken,—one from a plot rather free from organic matter, the other from sod land or soil otherwise rich in organic matter.
2. Take steel cylinder (Fig. 5), a heavy block of wood and an axe or hammer. Select a place as free from stones as possible in the cultivated ground. Carefully drive cylinder into the earth to a depth of seven inches. Dig out around it with a spade and remove. Transfer the soil from within the cylinder to an oilcloth or paper and from there to a glass jar. (In lieu of the cylinder method, samples may be taken with a spade. Equal volumes may be compared by measurement in tubes or cans filled and packed equally.)
3. Repeat the same process in the sod land.
4. Bring the samples of soil to the laboratory and weigh each carefully.
5. Weigh out 100 grams of each soil and determine the amount of capillary water in each.
6. Make the following calculations, using the entire samples, or equal volumes of each.

Soil	Part of acre	Lbs. of soil	Weight of furrow slice	Apparent sp. gr.	Per cent. of capillary water
Cultivated.....					
Sod.....					

QUESTIONS

1. Describe the color and physical appearance of the two soils.
2. Which weighs the more and why?
3. Which do you think would retain the more water?
4. Which soil has the greater apparent specific gravity? Why?
5. Which soil has the greater porosity? Why?
6. Which soil would the farmer consider the more productive?
7. State clearly the influence of constant tillage upon the organic matter in the soil.

(32)

EXERCISE 10

OTHER EFFECTS OF ORGANIC MATTER

PURPOSE.—To study the effects of manure and organic matter on the water-holding capacity of the soil.

PLAN

Use the following soils: (1) sand; (2) sand with 10 per cent well-rotted manure; (3) sandy loam; (4) sandy loam with 10 per cent well-rotted manure; (5) muck; (6) sand with 40 per cent muck.

1. Take six glass or metal percolators (Fig. 13) and in the bottom of each place a small piece of folded filter paper. If necessary moisten the filter paper in order that it may cover the bottom opening well.
2. In percolator No. 1 place 500 grams of sand.
3. Weigh out 450 grams of sand and mix thoroughly with 50 grams of well-rotted manure. Place in percolator No. 2.
4. Place 500 grams of sandy loam in No. 3.
5. With 450 grams of sandy loam thoroughly mix 50 grams of manure and place in No. 4.
6. In percolator No. 5 place 500 grams of muck.
7. For percolator No. 6 thoroughly mix 300 grams of sand and 200 grams of muck.
8. Make the soil compact by allowing each percolator to drop six times upon a book from the height of two inches. Be careful to treat each the same.
9. Set glasses underneath each percolator and then add slowly to each sample 400 cc. of water.
10. When percolation has ceased measure carefully the amount of water which has come through. Subtract this amount from the amount of water which was added. This will give the amount of water held by the soil.
11. Record results in the following table.

Results

Kind of soil	Grams of water held by soil	Tons of water held by acre 7 in.
Sand		
Sand with 10 per cent manure . . .		
Sandy loam		
Sandy loam with 10 per cent manure .		
Muck		
Sand with 10 per cent muck		

12. Compute in tons the amount of water held by each mixture for an acre furrow slice, assuming such an amount to weigh 2,000,000 pounds.

QUESTIONS

1. What is the effect of organic matter upon the structure of the soil and upon its ability to retain moisture?
2. Why is some of the water which percolated through of a straw color?
3. What does this water contain and what harmful farm practice does it suggest?
4. How much manure should be applied per acre?
5. Which is the better farm practice, to apply 10 tons of manure per acre every 4 years or 20 tons every 8 years?
6. Give five distinct benefits from the use of manure.
7. Why is manure beneficial on muck land?
8. State clearly the best method of handling muck for the purpose of improving a sandy soil. (Brook's Agriculture, Vol. 1, pp. 90, 91.)
9. How do manure and muck differ in their power to improve the soil?

(34)

EXERCISE 11

INFLUENCE OF WEATHERING, ORGANIC MATTER, SAND AND LIME ON
A CLAY SOIL

PURPOSE.—To determine best system of management for a clay soil.

PLAN *

1. Take five of the shallow square pans and weigh into each 400 grams of pulverized clay.
2. To pan No. 3 add 100 grs. of muck and mix thoroughly with the clay.
3. To pan No. 4 add ten grs. of lime and mix thoroughly.
4. To pan No. 5 add 10 grams of sand and mix.
5. Leave pans 1 and 2 without addition.
6. Add water slowly and mix each with a steel spatula to a stiff puddled condition. Be very careful not to add too much water.
7. Take pan No. 1, which contains pure clay, and scratch with a knife blade to a depth of one-eighth of an inch one-third of the surface, arranging the scarifications one-fourth of an inch apart in both directions.
8. On a cold night set the untreated pan No. 2 out-doors and allow it to freeze solid in its wet state.
9. Set the other four pans away and allow them to dry out thoroughly.
10. Later examine the pans and answer the following questions.

QUESTIONS

1. State the effect of muck, lime, sand and organic matter on the hardness of a clay soil. Discuss.
2. Does the sand appear to have improved the tilth of the clay soil? Would it be profitable farm practice to apply sand to a clay soil? Why?
3. Does freezing tend to mellow and crumble a puddled clay soil? What does this indicate as to the time of plowing?
4. How are the ice crystals formed?
5. What influence do the checks have on the structure of the soil?
6. From the results of this experiment outline a system of management for a heavy clay soil.
7. How do commercial fertilizers compare with manure in improving a clay soil?
8. What form of lime would give the quickest results on a clay soil? (See next exercise).
9. How many pounds would you use per acre? How should it be applied?

* Adapted from Department of Soil Technology, Cornell University.

(36)

EXERCISE 12

EFFECT OF LIME AND OTHER CHEMICALS ON A CLAY SOIL

PURPOSE.—To show that some chemical materials cause the soil to become more mellow and to crumble more easily, while other materials have the opposite effect.

Flocculation is the collecting together of very fine particles into clots or granules.

PLAN

1. Powder thoroughly in a mortar four ten-gram samples of clay soil and place in glass bottles.
2. Fill the bottles about two-thirds full of water.
3. Leave the first untreated but add chemicals to the other three bottles according to the following table. Pour some of the solution into a beaker and then measure the exact amount with a graduate.
4. What difference do you notice in the appearance of the solutions in the four bottles?
5. Examine some of the material from each bottle under a microscope and make observations.
6. Allow bottles to stand and note time required for the particles to settle. Clean carefully the beaker and graduate after each solution is used.

Results

Kind of treatment	Appearance after $\frac{1}{2}$ hour	Time required to settle
No treatment.....		
20 cc. of lime water.....		
20 cc. of acid phosphate.....		
20 cc. of nitrate of soda.....		

QUESTIONS

1. What material did you find most effective in producing flocculation?
2. How is a clay soil benefited if its particles are brought together in flakes?
3. What form of lime would act the quickest on a clay soil?
4. What form of lime might be more satisfactory on a sandy soil?
5. How much should be used per acre on a sandy soil and how much on a clay soil?
6. Under what conditions would lime benefit a sandy soil?
7. Discuss the action of acid phosphate on the soil. Does it cause soils to become acid? How?
8. What effect has the continuous use of nitrate of soda upon soil structure?

(38)

EXERCISE 13

TOTAL MOISTURE DETERMINATION

PURPOSE.—To determine the total moisture content of field samples of different soils.

PLAN

1. Take four pint jars with tight-fitting tops. Secure, either from the field or greenhouse, according to directions from the instructor, moist samples of the following soils—sand, loam, clay, and muck. Bring to the laboratory.
2. Secure four round evaporating dishes and after numbering determine their weight. Next weigh into each a fifty-gram sample of the soil the moisture content of which is to be determined.
3. Place the samples in a drying oven the temperature of which is slightly above the boiling point of water and allow to remain for twelve hours. Later remove to a dry chamber and allow to cool. Weigh as quickly as possible. Then return to the oven and heat again and reweigh in order to be sure that all moisture has been driven off.
4. Determine the total moisture by dividing the weight of moisture by weight of dry soil.

Several samples of soil taken the same day from different fields will enable the student to determine the relative water-holding capacity.

In making the calculations net weights only must be used. Eliminate the weight of dish in each case.

Total Moisture

Soil	Weight of dish	Total water		Dry weight of dish and soil	Dry weight of soil	Per cent of moisture
		Weight of soil	Weight of dish and soil			
Sand						
Loam						
Clay						
Muck						

QUESTIONS

1. Make a drawing illustrating the availability to plants of the three kinds of water found in field soils.
2. State two ways in which soil moisture is lost.
3. What proportion of soil water is probably lost by percolation?
4. State the methods which may be used to prevent the loss of water.

EXERCISE 14

• CAPILLARY MOISTURE

PURPOSE.—The determination of capillary moisture in samples of field soil. *Capillary moisture* is that water which is held in the soil by surface tension of the soil particles. If soil is exposed to the air it can be entirely evaporated at room temperature.

PLAN

1. Take four pint jars with tight-fitting tops. Secure, either from the field or greenhouse, according to directions from the instructor, moist samples of the following soils: sand, sandy loam, clay, and muck. Bring to the classroom and, using the square soil pans, determine the moisture content of the soil, as follows:
2. Label with a wax pencil and weigh on the balances the empty pan. Then immediately weigh into it 100 grams of the moist soil as quickly as possible.
3. Do the same with the other soils.
4. Set the pans away carefully and weigh every few days until a nearly constant weight is reached.
5. At the completion of the experiment carefully preserve these soils and determine the amount of hygroscopic moisture in them according to directions as given in the following experiment.

The amount of capillary moisture which has disappeared into the air is indicated by the loss in weight. Calculate the percentage of capillary water, using the dry soil for the base.

Capillary Moisture

	Weight of pan	Weight, pan and soil	Dry weight	Dry weight, soil only	Loss in weight	Per cent capillary water
Sand.....						
Sandy loam						
Loam.....						
Clay.....						
Muck.....						

QUESTIONS

1. Of what use is capillary water for plant growth?
2. Which soil holds the most capillary water, and why?
3. Where does the supply of capillary moisture come from?
4. How does it reach the surface of the soil and how is it lost?

(42)

EXERCISE 15

HYGROSCOPIC MOISTURE

PURPOSE.—To determine the percentage of hygroscopic moisture in air dry soils.

PLAN

1. Number and weigh five evaporating dishes.
2. Into the above dishes weigh 25 grams of each of the five soils remaining from the exercise for the determination of the capillary moisture.

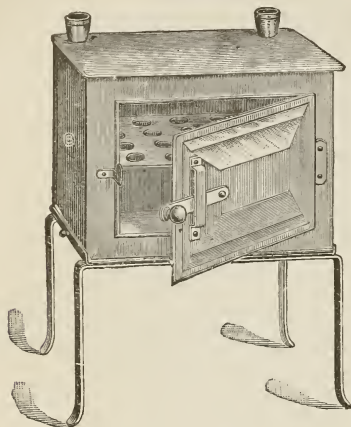


FIG. 8.—Drying oven with top tubes for thermometer and gas regulator.



FIG. 9.—Moisture-proof chamber for use in cooling oven-dried samples before weighing. Moisture-absorbing chemicals, as strong sulfuric acid, may be placed in the lower part to insure dryness.

3. Dry these samples in an oven (Fig. 8) which has a temperature slightly above the boiling point of water.
4. Later cover the dishes and remove from the oven and allow to cool in a dry chamber (Fig. 9).
5. Weigh rapidly and determine the loss of moisture.
6. Determine the per cent of hygroscopic moisture by dividing the weight of moisture lost by the weight of oven dry soil.

If possible the degree of humidity of the air in the room should be found on the day this exercise is conducted. If desired this exercise may be repeated on very dry and very wet days to determine the variation in amount of hygroscopic moisture.

Amount of Hygroscopic Moisture

	Weight of dish	Weight, dish and soil	Dry weight	Dry soil only	Loss in weight	Per cent hydr., water
Sand						
Sandy loam						
Loam						
Clay						
Muck						

QUESTIONS

1. Give a definition of hygroscopic moisture.
2. What three factors govern the amount of hygroscopic moisture in the soil?
3. State two possible ways by which this kind of moisture may be beneficial.

(44)

EXERCISE 16

CAPILLARY RISE OF WATER IN SOILS OF DIFFERENT TEXTURE

PURPOSE.—To determine the influence of the fineness of a soil upon the speed and total rise of capillary water.

PLAN

1. Close the ends of the large glass tubes (Fig. 11) by means of pieces of muslin firmly tied on.

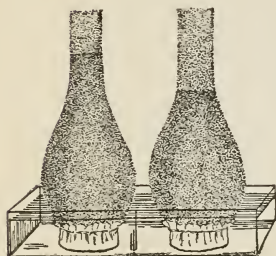


Fig. 10.—Handy equipment to show rise of water by capillarity.

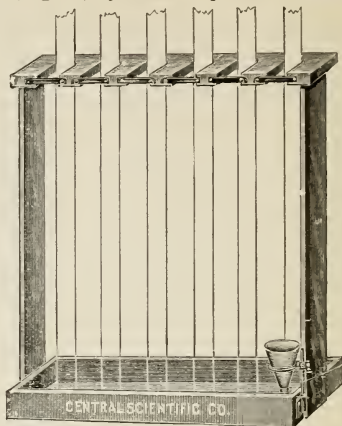


Fig. 11.—Frame and glass tubes for showing capillary rise of water in different soils.



Fig. 12.—Galvanized tray or tank to be used with the support for tubes in showing capillary rise of water. Also useful for exercise No. 17

2. Hold the tubes in a vertical position and carefully fill with their respective soils. After filling compact the soil by allowing the tubes to drop from a distance of four inches four times upon a book.
3. Place the tubes in a supporting frame (Fig. 11) over a rectangular pan of water, so that the ends are about one-half inch below the surface of the water (Fig. 12).

This experiment may be set up by the instructor but each student must fill out the following observation blank for himself as nearly at the time indicated as possible.

Rise of Water at Different Periods

Soil	$\frac{1}{2}$ hour	1 hour	3 hours	1 day	2 days	4 days	6 days	8 days
1.								
2.								
3.								
4.								
5.								
6.								

QUESTIONS

1. In what soil does the water rise the fastest? The highest?
2. Can you determine upon what factors the capillary rise of water depends? Give several.
3. Would a moist condition of the soil affect the total rise? Would it affect the rate?
4. Does capillary movement of water take place laterally? In a test of different fertilizers on field plots side by side, what effect would this have?
5. What does this experiment teach you concerning soil management and plant growth?

(46)

EXERCISE 17

EFFECT OF TOO MUCH ORGANIC MATTER ON RISE OF WATER

The water used by plants is conveyed to them largely by means of the process called capillarity.

PURPOSE.—To show that certain farm practices may be harmful, cutting off the water supply to plant roots by a layer of organic matter.

PLAN *

1. Tie a cloth firmly over the ends of two large glass tubes 18 inches long. Fill to the height of one foot with fine soil, compacted by letting the tube drop four times on a book for a distance of 6 inches for every 6 inches of soil put in the tube.
2. In one tube put about one inch of cut straw or sawdust; in the other about a half inch of well decayed fine manure. Finish filling the tubes with soil. Place the ends of the tubes in a tray of water and note the rise of water.
3. In this exercise each student must make daily observations on the heights of the water in the tubes and note the effect of organic matter on the rise of water.

Results

	Height of water
Soil with fine manure.....	
Soil with cut straw.....	

QUESTIONS

1. In which soil does the water rise the higher and why?
2. What is the effect of plowing under poorly rotted manure, straw, or a heavy green crop in the spring?
3. What damage to the ensuing crop might result if a heavy sod were plowed under late in the spring?
4. Would there be any advantage in rolling the land directly after plowing?
5. What advantage with relation to organic matter does fall plowing have?

*Adapted from Mosier.

(48)

EXERCISE 18

PERCOLATION OF WATER THROUGH SOILS

Percolation is the passage of water through soils by means of the natural channels.

PURPOSE.—To study the influence of texture and structure upon the passage of water through soils.

PLAN

1. Take six soil tubes (Fig. 13): fill three of them with the three different soils to within one-half inch of the overflow pipe, pouring it in loosely.



FIG. 13.—Percolation soil tube. In comparing the percolation of water through several soils the tubes are placed in the support block (Fig. 14) and are connected by rubber tubing attached to the lateral inlets. A beaker is placed under each drainage tube.



FIG. 14.—Support block for use in holding tubes with drainage outlets.

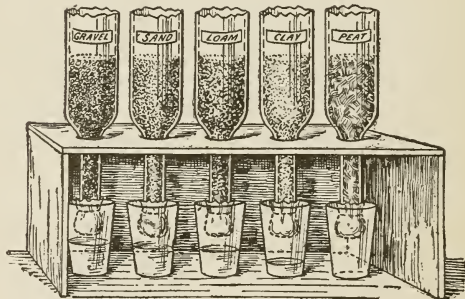


FIG. 15.—Another simple form of apparatus to show percolation of water through soils.

2. Fill the other three tubes with their respective soils, packing in the usual way by dropping or by using the compacting machine.
3. After all the tubes are full place a layer of coarse sand one-half inch deep over the top of each. This will prevent the water as it flows from disturbing the soil below.

4. After placing the tubes in the support block (Fig. 14) connect the tubes at the top with rubber tubing and place beaker glasses underneath them to catch the water which comes through.
5. Record the time elapsing after water is turned on until it begins to percolate through each tube of soil.
6. Determine the quantity of water draining through each soil in thirty minutes after it begins.

NOTE.—This exercise could be tried with five soils as suggested in Fig. 15.

Percolation of Water Through Soils

	Sand		Loam		Clay	
	Loose	Compact	Loose	Compact	Loose	Compact
Minutes for percolation to begin						
Amount of water percolating in 30 minutes						

QUESTIONS

1. Upon what two main factors does percolation depend?
2. Would water percolate faster through soil which was dry at first or through wet soil? Why?
3. What conditions in the soil assist percolation?
4. Is a sandy soil objectionable when percolation is considered?
5. What does this experiment indicate concerning the depth of plowing?
6. Would growing crops be benefited by a loose condition of the surface soil?
7. Would there be any advantage in fall plowing? Why?
8. Why are clay soils often wet?
9. What does this experiment indicate concerning the comparative depth at which tile drains should be put in a clay soil and in a sandy soil?

EXERCISE 19

CLOD FORMATION

PURPOSE.—To study the clod-forming properties in soils of different kinds.

PLAN

1. Take small samples of each of the available soils of the region; include a sample of heavy clay soil; also include one mixture of sand with clay and one of humus and clay.
2. On a mixing board mix each with enough water to make as stiff a "putty" as each sample will make. Roll part of it into the form of an inch marble, and another part into a half-inch cylinder about four inches long.
3. Make up all the samples as nearly alike as possible. Label each by stippling a number on each kind. Put the molded samples into cigar boxes or on shelves to dry for several days.
4. Make studies of the relative breaking powers of these samples, and make a record of their clod-forming properties.

Clod Formation

Kind of soil	No.	Crushing strength of marbles	Breaking strength of sticks	Remarks

NOTE.—If instruments are not available for measuring, crushing and breaking strength, comparisons may be made after breaking with fingers.

QUESTIONS

1. Make a list of the samples in order—the hardest clods first.
2. What interest has the farmer in the clod-forming properties of field soils?
3. Which soils must be handled most carefully after rains?
4. Which are likely to form hard crusts during dry weather if improperly managed?
5. Which soils will work up into the most perfect seed beds for gardens?
6. Why should clay soils, if plowed rather wet, not be allowed to dry before harrowing?
7. Give other points in the proper management of clod-forming soils.

EXERCISE 20

(53)

SOIL SURFACE AND PERCOLATION

PURPOSE.—To study the relationship between soil surface and the percolation of free water.

PLAN

1. Secure three or more small glass tubes of uniform length (about one foot) and place them in a jar of water deep enough to fill them to the top. Place the finger or palm of the hand against the top of the tubes and with the other hand remove the bundle of tubes from the jar of water. Hold the bundle in a vertical position and note that the water remains in the tubes. Now remove the hand from the top and see how quickly the water descends.
2. Fill two soil tubes (Fig. 16) with clay loam, packing them alike. Set them in a jar of water until saturated. Loosen the surface of one with a kitchen fork; smooth the surface of the other with the bowl of a wet spoon to avoid the free entrance of air. Then set the tubes of soil so as to drain into beaker glasses. Compare the rates of drainage of free water from the two tubes as a result of the difference in treatment of the surfaces.

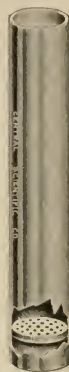


FIG. 16.—Common soil tube, 2" x 12" with perforated bottom, useful in many exercises.

	Surface smooth	Surface stirred
Amount of water in 1 hour.		
Amount of water in 2 days.		

QUESTIONS

1. Why does the exclusion of air at the top of the tubes retard percolation?
2. Does a heavy soil beaten by rain or puddled by free water standing on the surface tend to exclude the air? Explain.
3. What treatment can be given to the surface of field soils after heavy rains before they are quite dry enough to plow well?
4. Does a heavy, thick, dry, crust tend to exclude air from the soil more than a loosened surface? Explain.
5. Would harrowing tend to let the free water downward? Why?

6. When air is admitted to the soil in very early spring, what effect does it have upon the soil temperature? Explain.
7. In early spring is it better to allow the surplus water to percolate downward into the soil or to wait for it to evaporate from the surface? Give reasons.
8. If free water is caused to percolate below the depth of tillage in spring, what benefit may it have upon crops during subsequent dry weather?

EXERCISE 21

(55)

CAPACITY OF LOOSE AND COMPACT SOILS TO HOLD WATER

PURPOSE.—To study the influence of the texture and structure of different soils upon their capacity to retain water.

PLAN

Use four soils—sand, loam, clay, and muck.

1. Select eight soil cylinders (Fig. 16) and place a circular piece of filter paper in the bottom of each. Number and weigh each cylinder carefully.
2. Fill the first four tubes to within exactly one inch of the top, pouring the soil in gently so that it will rest in the tube in a very loose condition.
3. Fill the second lot of tubes to within one inch of the top and pack uniformly by the dropping method or by means of the compacting machine.
4. Weigh and record weights of filled tubes.
5. Place the tubes in a galvanized iron tank and pour water around them until it reaches the height of the surface of the soil, thus allowing the water to percolate up through.
6. Let stand until moisture appears at surface of soil in each cylinder, noting time required for water to come up through.
7. Finally remove the tubes from the tank and, after wiping off all free water with a cloth, weigh immediately upon balances.
8. Place cylinders in racks where the water may be allowed to percolate out, and cover top with a glass plate to prevent evaporation.
9. Weigh the cylinders according to the time indicated in the table.

Water Holding Power of Soils

	Loose				Compact			
	Sand	Loam	Clay	Muck	Sand	Loam	Clay	Muck
Number of tube.....								
Weight of tube.....								
Weight, tube and soil.....								
Weight of soil.....								
Time for top to become moist								
Depth, dry soil.....								
Depth, wet soil.....								
Moist weight, tube and soil...								
Weight of moist soil.....								
Water taken up, grs.....								
Water taken up, per cent....								
Grs. water lost, 1 hour.....								
Grs. water lost, 2 days.....								
Grs. water lost, 4 days.....								
Grs. water lost, 6 days.....								
Total water lost, grs.....								
Total water lost, per cent....								
Acre inches water retained....								

QUESTIONS

1. When a soil is saturated does it contain both free water and capillary water? Give reasons for your answer.
2. What per cent of water was found in each of the soils when saturated?
3. What relation does this proportion bear to the pore space of the soil?
4. What did you observe concerning the expansion of a muck soil when wet? What does this show concerning the depths at which tile drains should be placed?

5. From the results secured, what type of soil would you say would be most benefited by cultivation?
6. Which soils would leach most?
7. What effect does rolling have upon soil moisture?
8. What effect does fall plowing or early spring plowing have upon soil moisture?
9. Define gravitational water. What are its uses and when is it injurious?

EXERCISE 22

EFFECT OF EVAPORATION ON SOIL TEMPERATURE

PURPOSE.—To show that soils are cooled when water evaporates from them.

PLAN

1. Take two dairy thermometers which agree in their reading. Tie a few inches of cloth around the bulb of one thermometer and suspend the lower part of the cloth in a glass of water that is slightly warmer than the room.
2. From time to time note the difference in readings of the two thermometers, and decide how much difference is produced by evaporation of water from the cloth.

QUESTIONS

1. Show the analogy between this exercise and the evaporation of water from soils.
2. Would soils be kept cold by water evaporating from them in the spring of the year?
3. How many units of heat are absorbed or dissipated by the evaporation of one unit of water (see any text-book on physics).
4. Why should farmers wishing to warm their soils in early spring, prevent the evaporation of water from them? Would harrowing do this?
5. If harrowing produces a dust mulch and checks evaporation, would the free water below the surface be held there or tend to find its way downward?
6. Would the loosening of the surface crust of the soil tend to check downward percolation of soil water or increase it?
7. Would the loosening of the soil crust increase or retard the entrance of warm spring air?

QUESTIONS

1. What is the average annual rainfall for the country in which you live?
2. How many inches of water are used by a (a) 400 bushel crop of potatoes, (b) 100 bushels of corn, (c) 3.5 tons of hay?
3. How many inches of water may be lost by evaporation from a bare soil?
4. Which artificial mulch is the most efficient and which is the least efficient?
5. How does a mulch prevent loss of water by evaporation?
6. Which is the more economical, a natural or an artificial mulch?
7. Which mulch would need renewal the more often, clay or sandy loam, and why?
8. Why should cultivation always be done soon after a beating rain?
9. What is the best depth for cultivation? Why?
10. What effect will cultivation have on a very wet soil?
11. What effect do you think mulches would have upon the temperature of a soil?
12. What effect would scattering a light coating of manure upon meadows have upon the grass plants during hot, dry weather?
13. What influence does rolling have upon the evaporation of water from soil?
14. What can you say about the use of corrugated rollers?

EXERCISE 24

(63)

OPTIMUM AND CRITICAL MOISTURE

PURPOSE.—To determine optimum and critical moisture content and amount of available moisture in different soils.

Optimum moisture content is that amount of water in the soil with which a plant is able to make its best growth.

Critical moisture content is the minimum amount of water with which a plant is able to survive.

PLAN

1. Take five one-gallon glass battery jars (or tin cans) having a small hole close to the bottom. Into the hole fit a drain tube made of glass tubing with a glass-wool filter at the inner end, so that it will take liquid from the lowest place in the jar.
2. Weigh each jar and record weight.
3. Fill each jar to within one inch of the top with soil compacted to a moderate degree. Use the sand, sandy loam, loam, clay and muck.
4. Pour the soil out and mix with water until the soil is in the best possible field condition. Keep careful record of the amount of water added to each soil.
5. Fill the jars with the moist soil and weigh.
6. Plant five kernels of corn three-fourths of an inch deep in each jar.
7. Cover the tops of the jars with oileloth or waxed paper to prevent evaporation until the corn is up.
8. Water them at intervals when necessary, adding enough water so that a drop or two will be forced out at the drain. Always add the same amount of water to each pot.
9. When the corn is a foot high, cease watering and record the number of days before the plants commence to wilt.
10. Then empty the pots and determine the amount of capillary moisture in each soil.

Optimum and Critical Moisture for Corn

	Sand	Sandy loam	Loam	Clay	Muck
Weight of jar.....					
Amount of water.....					
Weight filled jar.....					
Per cent of water.....					
Amount of water added.....					
Number of days to wilt.....					
Per cent of moisture in soil at wilting ..					

QUESTIONS

1. Which of the soils has the largest amount of available moisture?
2. Which soil will store up the largest amount of moisture?
3. If each soil should have the same amount of water to commence with, on which would the crops wilt the quickest?
4. What is the water content of green alfalfa, corn, turnips, and potatoes?
Of straw, hay, ensilage, and shelled corn?

(66)

EXERCISE 25

DRAINAGE AND SOIL TEMPERATURE

PURPOSE.—To show the influence of standing water in a soil upon its temperature.

PLAN *

1. Prepare two similar vessels—one water tight and the other with holes to allow of good drainage at the bottom; these may be two tubs or boxes. Fill them with the same kind of soil to a depth of six inches.
2. Plant an equal number of grains of corn in each box.
3. Sprinkle equal quantities of water upon each vessel until it begins to drain from the box with the perforated bottom. Repeat this as often as is necessary until the corn is well up.
4. After ten or twelve days insert the thermometers and determine hourly the temperature of each at 1, 2 and 4 inches in depth.

Results

Time	1 inch deep		2 inches deep		4 inches deep	
	Drained	Undrained	Drained	Undrained	Drained	Undrained
9 o'clock.						
11 o'clock.						
1 o'clock						
3 o'clock						
5 o'clock						

Date of recording thermometer readings.....

No. of plants on drained soil..... On undrained soil.....

QUESTIONS

1. Why is there a difference in temperature?
2. Why are clay soils often cold or colder than sandy soils?
3. Why does corn often rot in the ground during a wet spring?
4. Name some of the benefits of drainage to the farmer.
5. What is the difference between natural drainage and artificial drainage?
6. Why is the latter necessary and what is the most successful method of carrying it out?

*Adapted from Mosier.

(68)

EXERCISE 26

COLOR AND TEMPERATURE

PURPOSE.—To determine the effect of color of soil on temperature. The temperature of the soil influences indirectly the yield per acre.

PLAN *

1. Secure four wooden boxes approximately 12 inches square by eight inches deep. Bore holes in the bottom for proper drainage. Fill with a uniform lot of loam soil to within one-half inch of the top.
2. Plant corn in one-half of one box at a uniform depth and a like number of kernels in the other half.
3. Cover the one-half of the soil with chalk dust or white sand and the other with lamp black or very dark humus soil. Be careful that the depth of the seed is the same after these covers are put over the soil.
4. In each of the other boxes plant equal numbers of wheat, beans and buck-wheat. Use the same light and dark covering as in (3).
5. Moisten all the soil equally from time to time.
6. Place the boxes where the sun will reach all the soil surfaces equally.
7. Record in the table the number of plants up, in each half box twice a day.

Number of Plants up Each Morning and Evening

Number of days	Light soil				Dark Soil			
	Corn	Wheat	Beans	Buck-wheat	Corn	Wheat	Beans	Buck-wheat
A. M.								
P. M.								

8. Select a clear day and make observations on the temperature of each half of one box. Insert a thermometer one-half inch, and another four inches deep, also place one two inches above the surface. Take readings every two hours and record in the temperature table.
9. Each student should make observations on all plots and keep results in tabular form.

*Adapted from Mosier.

Record of Temperature—Thermometer Readings

Location of thermometer	Temperatures				
	9 A. M.	11 A. M.	1 P. M.	3 P. M.	5 P. M.
Light soil					
2 inches above					
½ inch in soil					
4 inches in soil					
Dark soil					
2 inches above					
½ inch in soil					
4 inches in soil					

QUESTIONS

1. Explain why one soil is heated more than the other.
2. What effect does organic matter have on the color of soil? Why?
3. On which soil do the plants appear quickest?
4. Which kind of plants show first?
5. Give in their proper order the general dates for planting winter wheat, spring wheat, corn, mangels, cabbages, oats, potatoes, barley, alfalfa, clover, beans and other field and garden seeds. State the temperature at which each of these plants germinates the best.
6. Name six conditions which influence soil temperature.
7. What effect has (a) rolling, and (b) harrowing upon the temperature of the soil?
8. Show by means of a diagram how the slope of the land may influence the temperature.

EXERCISE 27

(71)

SOIL VENTILATION

PURPOSE.—To demonstrate the practical importance of soil ventilation and drainage, and to call attention to the manner in which the soil ventilation may be affected by the structure of the soil.

PLAN*

1. Secure four round pans about 8 inches deep. (Gallon cans will do.)
2. Fill two of the pans to within one and one-half inches of the top with loose clay soil which has a good field condition of moisture. Then plant twenty grains of corn in each pan by laying the corn on the surface of the soil and placing an inch of soil over the grains.
3. Fill the third pan to the same height with the same kind of soil in a very compact condition. Plant twenty grains of corn in the same manner as before, except compact the soil over the grains. Prepare soil for Nos. 1 and 3 together.
4. Avoid puddling by giving plenty of time for diffusion of water. Great care is necessary to secure the right moisture conditions.
5. Make a germinating pan of the fourth by filling it half full of sand. Place twenty grains of corn on the sand and cover with moist filter paper.
6. Keep the pan moistened as shown in table and cover with oilcloth or waxed paper until seedlings are well up.
7. See that the different pans are kept under the proper moisture conditions.
8. Observe the rate and percentage of germination each day in the shallow pan.
9. At the end of ten days examine the pans closely and make the following observations.

Ventilation and Germination

No. of pan	Treatment of soil	Per cent of germination	Strength of growth	Appearance of seedlings	Remarks
1.....	Loose, moist.....				
2.....	Loose, wet.....				
3.....	Compact, moist.....				
4.....	Germination pan, moist				

*Adapted from Department of Soil Technology, Cornell University.

QUESTIONS

1. What is soil ventilation?
2. What is the effect of compacting the soil on the germination of the seeds?
3. What effect did the wet condition of the soil have on the germination and growth?
4. Is either compactness or excess of water likely to occur in sandy soil?
5. What would be the effect of tile drainage on soil aëration in a heavy clay soil?
6. Name the different forces which serve to change the air in the soil.
7. Of what importance is ventilation to the bacteria which live on clover and alfalfa roots?
8. What relation has ventilation to the decay of organic matter in the soil?
9. State clearly why soil ventilation is important.

Grade.....

Date.....

(74)

EXERCISE 28

AMOUNT OF ORGANIC MATTER IN SOILS

PURPOSE.—To compare roughly the relative amounts of organic matter in two different samples of field soils.

PLAN

1. Place a small amount of each soil in an evaporating dish and heat for several hours in an oven in order to drive off hygroscopic moisture.
2. Number and carefully weigh on sensitive balances two or more crucibles with covers.
3. Place in each crucible ten grams of the previously dried soil and ignite at a glowing temperature for an hour. Lift the cover occasionally to allow gases to escape.
4. After the samples have been cooled in a closed chamber, weigh again and determine the loss of each.
5. The loss in weight of each sample is largely due to the burning away of the organic matter. A part of the loss is due, however, to the escape of water, of crystallization, etc.
6. Students having time for extra laboratory practice should test other samples for organic matter.

Results

Soil	Weight crucible	Weight, crucible and soil		Loss, grs.	Loss, per cent
		Before ignition	After ignition		

QUESTIONS

1. Do uplands or lowlands usually contain the most organic matter? Why?
2. Is the percentage of organic matter present in any soil a good indication of its fertility?
3. Do soils containing much organic matter plow easier or harder than others?
4. What is meant by active and inactive organic matter and what is their relative importance? Give examples of each.

5. What is humus and how does it differ from organic matter?
6. How much organic matter is there in an acre of normal soil?
7. Give six of the most important benefits of organic matter.
8. Show clearly how the supply of organic matter may be maintained in different types of farming.

(76)

EXERCISE 29

ABSORPTION OF PLANT FOOD BY SOILS

PURPOSE.—To show the power of soils to absorb soluble food materials and humus and the influence of lime on this process.

PLAN*

- Place six glass or metal percolators in the rack in their proper order. Fold small pieces of filter paper to be carefully inserted in the base of each percolator.
- Fill the percolators with soil as follows:
 - No 1. 400 grams of clay loam.
 - No. 2. 400 grams of clay loam.
 - No. 3. 400 grams of clay loam with which there has been mixed 5 grams of lime.
 - No. 4. 400 grams of sandy loam.
 - No. 5. 400 grams of sandy loam.
 - No. 6. 400 grams sandy loam with which there has been thoroughly mixed 5 grams of lime.
- Add the following solutions to the designated portions of soil:
 - Funnels Nos. 1, 3, 4 and 6—300 cc. of manure extract.
 - Funnels Nos. 2 and 5—300 cc. of potassium permanganate solution.
- Note carefully the rate of passage of the liquid through different portions of the soil. Collect and examine the first five cc. of solution that passes through the stem of each funnel, comparing its color with subsequent portions of the original liquid, and the different treatments one with the other.

Absorption of Plant Food by Soils

Kind of soil	Lime treatment	Solution treatment	Time required for 1st drop	Color of 1st portion of percolate	Color of latter portion of percolate	Reaction, litmus	Remarks
Clay loam	No lime	Manure extract					
	No lime	Permanganate					
	Limed	Manure extract					
Sandy loam	No lime	Manure extract					
	No lime	Permanganate					
	Limed	Manure extract					

*Adapted from Department of Soil Technology, Cornell University.

QUESTIONS

1. What is absorption?
2. How is the manure extract affected in passing through the soil?
3. How does lime affect the process?
4. What is leaching?
5. What kind of soil would lose most by leaching?
6. Would you follow the same method for applying nitrate of soda on a sandy soil as on a clay soil? Why?
7. Which of the above two soils would be best plowed in the Fall? Why?
8. What does this experiment teach us?

(78)

EXERCISE 30

TESTING SOILS FOR ACIDITY

PURPOSE.—There are three common tests for soil acidity. Any one of these should furnish fair evidence as to the need of the soil for lime. An agreement of the three tests should furnish conclusive evidence regarding the condition of the soil. The purpose of this exercise is to familiarize the student with the manipulation of these tests.

PLAN

Samples of the surface soil and subsoil of a soil well stocked with lime and samples of acid soils should be supplied. Acid phosphate, lime, fresh muck, wood ashes, silage, and horse manure also may be tested.

- I. *Litmus Paper Test*.—Take a tumbler with a smooth bottom. By means of forceps or the tips of the fingers select two pieces of litmus paper, one blue and the other neutral, and drop into the tumbler. Then cut a disk of filter paper and place in the bottom of the tumbler over the litmus paper. On top of this place two or three tablespoonfuls of the moist soil to be tested. If the soil is not moist enough add a small amount of rain or distilled water. Take a handful of the same soil and squeeze into a ball. Break the ball and in the center insert a piece of blue litmus paper. With both of these tests, if the soil is acid, the litmus paper should show a decided pink.
- II. *Ammonia Test*.—Take two tumblers and fill each about three-quarters full of distilled or rain water. To the first add a few drops of common ammonia. Then into each tumbler stir a tablespoonful of the soil to be tested, being careful to use two spoons and keep each in its respective glass. Stir the contents of each glass thoroughly for three or four minutes and set aside for a few hours. At the end of that time examine the contents of each glass. If the soil needs lime the water standing above the soil in the glass in which the ammonia has been added will have a dark, reddish-brown or black appearance, while the water in the other glass will be very nearly clear. On the other hand, if the soil is well stocked with carbonates of lime or magnesia, the soil water in both glasses will be entirely clear.
- III. *Hydrochloric Acid Test*.—Place a small quantity of soil in an evaporating dish and pour on this three or four drops of hydrochloric acid. If bubbles escape it is a sign that there is an abundance of carbonates. If there is no effervescence the soil lacks carbonates and is probably acid.

Color or Action of Indicator

Name of test	Surface soil 1	Subsoil 1	Surface soil 2	Subsoil 2
Litmus paper (tumbler)				
Litmus paper (ball) ..				
Ammonia				
Check.....				
Acid.....				

QUESTIONS

1. What effect have the moist fingers upon litmus paper?
2. Write the reaction which occurs when carbonate of lime or other bases in the soil are acted upon by hydrochloric acid.
3. Why does the washing of an acid soil in the presence of ammonia have a brown color?
4. Why is it necessary to test the subsoil as well as the surface soil?

Grade.....

Date.....

(80)

EXERCISE 31

EXAMINATION OF CHEMICAL FERTILIZERS

Fill a column as nearly as possible for each sample of fertilizer examined.

	Sample 1	Sample 2	Sample 3	Sample 4
Fertilizer.....				
Source.....				
Amount of: Nitrogen.				
Phosphoric acid....				
Potash.....				
Lime.....				
Color.....				
Smell.....				
Taste.....				
Crystal, powder, etc.				
Deliquescent.....				
Keep well.....				
Availability:				
Immediately.....				
Quickly.....				
Slowly.....				
Very slowly.....				
Cost per ton.....				
Value per lb. of:				
Nitrogen.....				
Phosphoric acid....				
Potash.....				
Remarks:.....				

QUESTIONS

1. How would you distinguish nitrate of soda from muriate of potash?
2. How does rock phosphate differ from acid phosphate?
3. Is the phosphoric acid in dissolved bones more available than in acid phosphate?
4. How does dried blood differ from tankage?
5. What is the use of peat or muck in mixed fertilizers and what is its fertility value?
6. Is lime a good material to use with mixed fertilizer and why?

(82)

EXERCISE 32

STUDY OF PLOWING

“The art of agriculture will never rise higher than the man who manages the land.”

Plowing is the oldest, the most fundamental and far-reaching operation in soil management. In perhaps no other farm operation is the character and skill of a man reflected so strongly as in the furrow which he turns with his plow. The freshly turned earth, as well as his horses and plow, are all silent witnesses (Fig. 18).

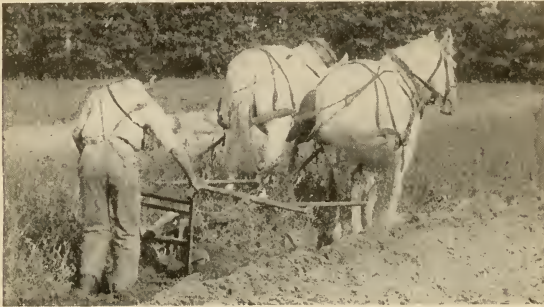


FIG. 18.—Preparing himself for a soil-plowing contest.

SCORE CARD FOR PLOWING

	Perfect Score				
Striking out land.....	20				
Line of furrow.....	15				
Proper inversion of furrow slice	15				
Soil properly pulverized.....	5				
Furrow of uniform width.....	10				
Furrow of uniform depth.....	15				
Trash covered.....	10				
Ends and corners.....	5				
Handling team.....	5				
Total.....	100				

THE PLOW AS ADAPTED TO PURPOSES

1. Shape of mold board (Figs. 19, 20 and 21)	10
2. Selection and adjustment of coulter and jointer	15
3. Condition of wearing surfaces and cutting edges	20
4. Adjustment and hitch of plow	15
5. Weight	5
6. Draft	5

The Native Power

7. Size and ability of team to do work	5
8. Harness	5

Condition of Soil for Plowing

9. Soil in proper moisture condition	10
10. Proper depth and width of furrow	10

Total 100

Texture and condition of soil
 Width of furrow Depth
 Remarks:

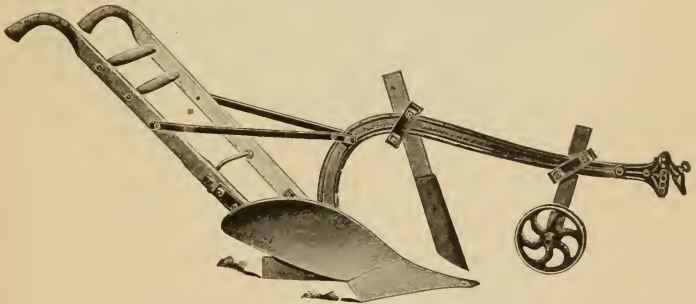


FIG. 19 —Sod plow which does not pulverize the soil very much. Moldboard long and gently curved.

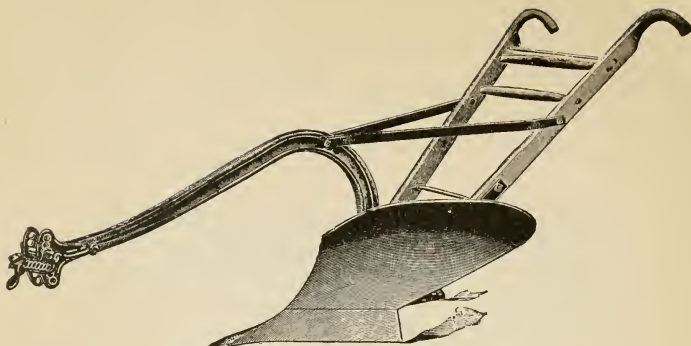


FIG. 20.—Stubble plow, with a steep moldboard abruptly curved.

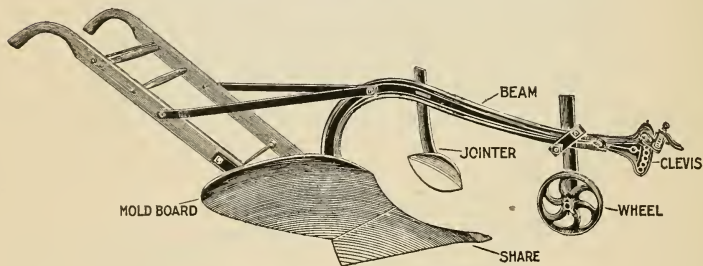


FIG. 21.—General purpose plow.

EXERCISE 33

(85)

EXAMINATION AND DISCUSSION OF TILLAGE MACHINERY

Plows.....	{ Side hill or reversible Landside (walking) Sulky (one way) Sulky (two way) Disk	
Harrows.....	{ Full disk Cutaway Spading	Spring tooth Spike tooth Acme Meeker
Cultivators.....	{ Riding Coulter (common) Spiketooth Spring tooth	
Soil Firmers.....	{ Solid Roller Corrugated roller	Packer and mulcher Planker

QUESTIONS

1. Make a drawing of a section of each one of these harrows.
2. When should fall plowed land be harrowed?
3. When should spring plowed land be harrowed?
4. If a man could have but one harrow what one should he choose?
5. Under what conditions would each one of the disk harrows give the most satisfactory results?
6. If a soil on a certain farm is somewhat uniformly a medium loam what two harrows would be the most economical to purchase?
7. Describe the work of the Acme harrow.
8. What type of work leaves the soil the lightest and loosest and which one compacts it the most?
9. Which harrow works the soil the deepest?
10. Which harrow is adapted to the interculture of crops?
11. Why should harrows be as wide as possible?
12. What are the advantages of the corrugated roller?
13. What are the advantages of rolling and when should it be done?
14. What type of cultivator is the most popular and why?
15. Make a drawing of the different types of coulters and jointers used on plows. State clearly the use and value of each.
16. What are the advantages of the planker?

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