AGRICULTURAL LABORATORY MANUAL-SOILS

SELL

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SOILS

BY

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PREFACE

The exercises in this manual have been planned for high schools, for agricultural high schools, and for normal schools. There are probably more exercises than most teachers will care to use in the study of soils, but this will afford an opportunity to select the exercises that are best suited to the conditions and the material at hand.

The exercises are so arranged that students may make the necessary notes with the minimum amount of time and trouble. Many teachers will find it an advantage to remove the sheets and give them to the students as needed. For some of the exercises it would not be necessary to have sufficient equipment for all the students to work with the same exercise at the same time.

Accuracy in weighing materials and in performing the experiments should be demanded of the students. This is not only necessary in order to secure the best results, but it is a good way to teach accuracy in all things.

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LIST OF MATERIAL AND APPARATUS NEEDED

Beakers
Fruit jars
Funnels
Filter paper
Compound microscopes
Pie tins
Tomato cans
Balances, sensitive to .1 gram
Soil tubes and stands
Ring stands, with rings
Graduated cylinders
8-inch flower pots
Blue litmus paper
Lamp chimneys
Mill for pulverizing soil
Soil auger
Labels
Erlenmeyer flasks
Triangles
Glass tubes, $1\frac{1}{2}$ in. $\times$ 3 ft.
Capillary tubes
Crucibles
Drying oven
Bunsen burners or alcohol lamps
Compacting machine
Rubber tubing, $\frac{1}{4}$-in.
Soil thermometers
Wet-and-dry-bulb thermometers
Garden tools
Lime
Paraffin
Sand
Clay
Loam
Humus
Woods earth
Soot
Chalk boxes

The above material may be bought from various scientific-supply houses, but much of it should be bought locally.

EXERCISE 1

ORIGIN OF SOILS

Visit a road or a railroad cut. Find rocks that are disintegrating from the effects of freezing. Procure rocks that have not been affected by the "weathering processes," one that has been affected slightly, and another that is nearly ready to form soil.

Find evidences of the part plants play in soil formation — either by roots or by stems. Do plants grow better on the hillside or at the foot of the hill? Why? Describe below, the things you saw that relate to soil formation.

EXERCISE 2

SOIL PARTICLES AND THEIR SEPARATION

The day before separation is to be made, put about a tablespoonful of sand, loam, and clay soils, respectively, into a fruit jar two-thirds full of water. Cover and shake thoroughly. After it has stood for a day, shake thoroughly for fifteen minutes. Allow to settle for one minute. Pour off the roily water into a beaker. In order to get all except sand out of the jar, it is often necessary to pour a little more water into the jar, shake again, and let settle for one minute. Pour as before into the beaker. Be careful to pour all that will run from the jar.

Let the water in the beaker settle for thirty minutes; then filter all that will run from the beaker.

The particles left in the fruit jar will be sand; those in the beaker, silt; and those in the filter paper, clay.

Examine the separates and note differences. Give the relative proportions of sand, silt, and clay in each soil.

EXERCISE 3

MICROSCOPIC EXAMINATION OF SOIL PARTICLES

Examine sand particles magnified 75 diameters; silt, 75 diameters; and clay, about 500 diameters. Describe with reference to the following points:

Color — white, gray, red, brown, or black.

Shape — angular, rounded, or irregular.

Simple or compound structure.

Size — coarse, medium, or fine.

Find flocculated particles of clay (that is, a number of particles united to form a compound particle).

How do soils vary in regard to (1) size of particles, (2) simple or complex character of particles, (3) shape of particles?

EXERCISE 4

FLOCCULATION OF SOIL PARTICLES

Put a tablespoonful of clay into each of two beakers and fill each beaker nearly full of water. Stir well. Into one beaker put one-half ounce of lime. Stir the contents of each beaker again. Describe the effect that the lime has on settling the soil.

The effect of the lime was to combine the small particles into larger ones, thus making the clay settle to the bottom of the beaker more quickly. How would lime improve the mechanical condition of a clay soil?

EXERCISE 5

EFFECT OF WETTING ON THE GRANULAR STRUCTURE OF SOILS

Fill a shallow pan with clay soil; saturate thoroughly with water, and set in the sun to dry. Note the cracks that form after drying. What reason can you give for the formation of the large cracks? Wet again and dry. Do the cracks form as large as before? It may be necessary to repeat the process several times to bring about much difference in the granular structure. Describe the change effected in the soil. Would good drainage affect the granulation of a clay soil?

EXERCISE 6

WEIGHT OF SOILS

Fill three smooth tin cans level full — one with sand, another with loam, and another with clay. Compact the soil in each can by holding the filled can three inches above a book and allowing the can to drop on the book. Drop each can in this way three times. After the soil is thus compacted fill the cans level full and stroke the tops with a straightedge. Record the weights and fill in as indicated below. Empty the cans, refill with the same kind of soil, and weigh again for a duplicate determination.

Measure the diameter and the height of each can, and compute the number of cubic inches of soil contained in each. Calculate the weight of the soils per cubic foot. Calculate the weight of an acre to the depth of one foot, of each of the different soils.

Kind of Soil	Weight of Can	Can and Soil, First Weight	Soil, Second Weight	Average Weight of Soil	Volume of Can	Weight of Soil per Cubic Foot	Weight of Soil per Acre Foot
Sand							
Loam							
Clay							

EXERCISE 7

IMPORTANCE OF SOIL MOISTURE

Use a small, vigorous plant growing in a tomato can or flower pot. Cut a piece of cardboard so that it will fit about the plant and cover the can or pot. Seal the slit with paraffin or wax, so that no moisture can come up from below.

Put the plant in the sunshine and cover it with a glass jar. If moisture collects on the sides of the glass, where does it come from? Would you judge from this experiment that crops need large quantities of water?

EXERCISE 8

RELATION OF SIZE OF SOIL PARTICLES TO WATER-HOLDING CAPACITY

Place several small marbles or pebbles in a glass, and in another glass place soil equal in weight to the marbles or pebbles. Pour into the glass containing the marbles exactly enough water to cover them, and into the other glass pour exactly enough water to cover the soil. Pour off into separate dishes all the water that will run from each glass. From which glass does the more water come? Which glass retains the more water?

Soils made up of small particles hold more water than those made up of coarse particles, because the former soils contain a greater number of particles and therefore have a greater surface to hold water.

EXERCISE 9

FILM WATER IN SOILS

Weigh four jars with tight covers. Number them and label each with its number and weight. Secure a sample of loam from a field that has been cultivated, to put in jar No. 1. (To get samples of soil use a soil augur and take one half of the sample at a depth of six inches and the other half at a depth of twelve inches.)

Take a sample of loam from a place that has not been cultivated and that is hard and compact, and put it in jar No. 2.

Secure in the same manner from cultivated fields a sample of sandy soil for jar No. 3 and one of clay soil for jar No. 4.

Cover the jars tightly as soon as the soil has been put into them. Then, after they have been brought into the laboratory and weighed, uncover them and allow the soils to dry. The loss in weight will represent the amount of film, or capillary, water in the soils. Tell of the importance of film water to crop production.

	Cultivated Loam	Uncultivated Loam	Cultivated Sandy Soil	Cultivated Clay Soil
Weight of jar				
Weight of jar and wet soil				
Weight of jar and dry soil				
Per cent of water				

EXERCISE 10

WATER-HOLDING CAPACITY OF SOILS

Weigh carefully the soil tube, fill with sand, and compact by using the compacting machine.

Stand the tube in a vessel containing water to a height nearly equal to that of the surface of the soil, and leave the tube standing in this position until the surface of the soil becomes thoroughly moistened.

Remove the tube from the water, wipe dry, and weigh.

In the same way determine the weight of water taken up by loam, by clay, and by a mixture of loam and humus. The mixture of loam and humus should be about 25 per cent humus.

Tabulate the data as follows:

	Sand	Loam	Clay	Loam and Humus
Weight of tube				
Weight of tube and soil				
Weight of soil				
Weight of both and water				
Weight of water				
Per cent of water				

Which soil holds the most water? Why? What effect does the addition of humus have on the water-holding capacity of soils?

EXERCISE 11

CAPILLARITY

1. Procure a set of capillary tubes and place them in a beaker of water colored with ink. In which tube does the water rise the highest?

2. Put a piece of cloth over the end of each of three glass tubes three feet long. Fill one tube with sand, another with loam, and another with clay. Set all in water to a depth of about two inches and record the rise of the water in each at the close of the several periods of time indicated in the table below. The space between the soil particles may be compared to the capillary tubes. Why does the water rise higher in one soil than in another?

Time	Sand	Loam	Clay
One-half hour			
One hour			
One day			
Two days			

EXERCISE 12

EFFECT OF MULCH ON EVAPORATION

Procure three tin cans with holes in the bottom. Fill each about three-fourths full with soil. Pour water into the cans until it begins to drain out at the bottom. Allow the cans to drain for fifteen minutes. Cover the contents of the first can with a layer of dry soil to the depth of about one inch and keep this layer well stirred. Make the dry-soil mulch deep enough at first so that it will not become wet from the soil underneath. Cover the contents of the second can with a layer of finely cut straw, and allow the soil in the third can to remain uncovered and undisturbed. Weigh the cans every day for a week and tabulate the weights according to the form below.

Date	Uncovered and Undisturbed		With Cultivated-Soil Mulch		With Straw Mulch	
	Weight	Loss	Weight	Loss	Weight	Loss

EXERCISE 13

DETERMINATION OF HYGROSCOPIC MOISTURE, OF ORGANIC MATTER, AND OF MINERAL MATTER IN SOILS

Weigh three crucibles and record weights. Put 10 grams of soil in one, 10 grams of subsoil in another, and 10 grams of woods earth in the third. Heat for one hour at 110° C. Cool in desiccator. Weigh. The loss in weight is the weight of the hygroscopic moisture present in the soil at the beginning of the experiment. Now heat to a dull redness. After the crucibles have burned for one hour, cool them in desiccator and weigh. Compute and tabulate the results as indicated below.

	Soil	Subsoil	Woods Earth
Weight of crucible			
Weight of crucible and soil			
Weight of soil	10	10	10
Weight of soil after drying			
Per cent of water			
Weight of crucible and soil after burning			
Weight of organic matter			
Per cent of organic matter			
Per cent of mineral matter			

EXERCISE 14

RATE OF PERCOLATION OF WATER THROUGH SOILS

Use in this experiment sand, clay, and loam. Fill without compacting, within an inch of the overflow pipes, each of the three soil tubes provided for this experiment, with one of the soils named above, and place a half-inch layer of gravel on the surface to prevent disturbance of the soil by flowing water.

Connect the filled tubes with short pieces of rubber tubing, by means of the lateral inlets, and close with corks the openings at the extreme ends of the series.

Pour in water gently in quantities sufficient to keep the tubes almost level full and maintain the same water level in each tube.

Note the time which elapses before percolation begins from the drainage tubes, and then place an Erlenmeyer flask beneath each. When the flow becomes constant, collect and measure carefully the water which percolates through the soil of each tube in thirty minutes.

Determine in the same way the amount of water which percolates in thirty minutes through compact sand, clay, and loam.

Tabulate the results as follows:

Kind of Soil	Loose		Compact	
	Time for percolation	Cubic centimeters of water in thirty minutes	Time for percolation	Cubic centimeters of water in thirty minutes

EXERCISE 15

SOIL TEMPERATURES

To take the temperature of a soil, place the thermometer in the soil to a depth of about three inches and allow it to remain from ten to twenty minutes. Take the temperature on a northern and on a southern slope, also take the temperature of clay and of sand, and of unplowed and of plowed fields. In each of these three groups you will probably find the soil mentioned second the warmer. Why?

Temperature of soil on northern slope . . ..
Temperature of soil on southern slope..... .....
Temperature of soil of unplowed field..... . . . .
Temperature of soil of plowed field ....
Temperature of clay soils . . ..
Temperature of sandy soils ....

EXERCISE 16

EFFECT OF DRAINAGE ON TEMPERATURE

Fill the receptacle on the hygrometer with water. At the same time fill a beaker half full of water and place a thermometer in it. In about thirty minutes record the temperature of the air, of the wet bulb, and of the water in the beaker.

Why is the wet bulb colder than the water in the beaker? With other conditions the same, why is a well-drained soil warmer than a wet soil?

A wet-and-dry-bulb thermometer may be made by attaching two thermometers to a small board and tying a piece of cloth around the bulb of one of the thermometers. The cloth should be long enough to draw up water from a receptacle attached to the board and is by this means kept wet. A wet-and-dry-bulb thermometer is sometimes called a hygrometer.

Temperature of dry bulb.....
Temperature of water .....
Temperature of wet bulb.....

EXERCISE 17

RELATION OF COLOR TO TEMPERATURE OF SOILS

Fill two small boxes nearly full with loam soil. Cover one with chalk dust or lime and the other with soot. Bury the bulb of a thermometer about an inch deep in each box. See that the thermometers are placed at equal depths and perpendicular to the surface. Read the thermometers from time to time. Why are dark soils warmer than light ones? Results may be obtained more quickly by placing the boxes in the sunshine. Read the temperatures every ten minutes for one hour and record in the blanks below.

Kind of Soil	Temperature					
	At end of 10 min.	At end of 20 min.	At end of 30 min.	At end of 40 min.	At end of 50 min.	At end of 60 min.
Dark soil						
Light soil						

EXERCISE 18

EFFECT OF ROLLING ON TEMPERATURE

Pulverize the soil on two small plots in a field or garden. Leave the soil of one plot loosely prepared, and roll or pack the soil of the other plot. Place a soil thermometer to the depth of three inches in each plot and allow the thermometers to remain in the soil from ten to twenty minutes; then read the temperatures and record them in the blanks below.

If the weather is clear and warm, rolling will make the soil warmer, but if the weather is cloudy and cold, the effect will be to make the soil colder. For this reason the temperature of the soil in each plot should be taken several times, under differing weather conditions.

Date							
Temperature of rolled soil							
Temperature of loose soil							

EXERCISE 20

EFFECT OF DRAINAGE

Secure two 8-inch flower pots. Coat one with paraffin and cork the drainage hole in the bottom. Fill both pots with fertile soil and plant two or three grains of corn in each. Keep well watered until the plants grow several inches high. Make notes of whatever difference you find in the growth of the plants. Read the temperature of the soil in each pot at different times and record in the blanks below.

Is air necessary for plant growth? If the soil is filled with water, will the air be excluded?

Date						
Temperature of drained soil						
Temperature of undrained soil . . .						

EXERCISE 21

ONE EFFECT OF HUMUS AND LIME ON CLAY SOILS

Procure three quarts of clay. To one quart add water, to another add water and about one-fourth its volume of humus, and to the third add lime milk (lime milk is made by putting one tablespoonful of lime in about one-half pint of water). Make the clay thus treated into balls and set them aside to dry. When the balls become dry, pulverize them and note the hardness of each. What is the effect of working clay wet? What is the effect of humus and of lime on clay soils?

EXERCISE 22

EFFECT OF FREEZING ON SOILS

Puddle a pint of clay, mold it into a ball, and let it dry. In freezing weather moisten the ball and put it out of doors overnight. If it does not break up the first night, moisten it again and subject it once more to the action of frost. From this result, what would you say of the practice of fall-plowing clay soils? Is there any advantage in fall plowing other than that it pulverizes the soil?

EXERCISE 23

SOIL ACIDITY

Select at least three samples of soil from different parts of a field. Make a ball from each sample of soil, moistening if necessary. Break in two, place a piece of blue litmus paper between the parts, and press the soil firmly together again. After about five minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The amount of acidity is indicated to some extent by the intensity of the color and by the rapidity with which it develops.

Mark the place where each sample is selected and if a sample proves to be acid, study the location and type of soil as well as the general conditions existing where this particular sample was selected. What effect does acidity have on plants? on the growth of bacteria on legumes? What will correct soil acidity?

EXERCISE 24

EFFECT OF ROLLING SOIL

Plant radish seeds one inch deep in two flower pots. In both pots have the soil loosely prepared. After planting the seed, firm the soil in one pot, leaving that in the other loose. Note the time required to germinate the seeds in each pot.

Moisture is one essential of seed germination. If the soil is rolled, it brings more particles of soil in contact with the seed and therefore furnishes more moisture for germination.

EXERCISE 25

EROSION

Weigh a tomato can and fill it with water running in a ditch after a rain. Water flowing rapidly down a hillside will be better. Evaporate the water by boiling it until the soil which it contained is left dry. The results should be placed in the blank below. Would you consider the loss from erosion very great?

The soil that is lost by erosion is the most valuable that the farmer has because it is the finest and gives up its plant food the most readily.

Weight of can	
Weight of water	
Weight of soil	
Per cent of soil	

EXERCISE 26

POWER OF SOILS TO RETAIN PLANT FOOD AND FERTILIZERS

Tie a piece of cheesecloth over one end of each of three lamp chimneys. Fill one chimney within an inch of the top with sand; another, with clay; and the third, with loam.

Pour into the chimneys muddy water or manure liquid (to make manure liquid, fill a bucket one-fourth full of manure, fill with water, and let stand for one day). Place beakers underneath the chimneys to catch the water.

Note the color of the water after it has percolated through the soil. How does this show the ability of soils to retain plant food and fertilizers?

EXERCISE 27

BACTERIA IN SOILS

Secure a small sample of fertile soil and place on a slide in a few drops of water. Examine with a compound microscope that will magnify from 500 to 1000 diameters.

What shape do these bacteria have? Are there many?

EXERCISE 28

SOIL INOCULATION

Fill two 8-inch flower pots with good loam. The soil should be obtained from a field in which no alfalfa has been grown.

Plant a few alfalfa seeds in each pot. Inoculate the soil in one pot by using some soil from a field where alfalfa has been successfully grown or secure artificial cultures of bacteria. Describe the difference in growth of the plants in the two pots.

Bacteria for alfalfa may be obtained at any seed store or from the United States Department of Agriculture. This experiment may be conducted to better advantage on two field plots.

EXERCISE 29

EFFECT OF PLOWING UNDER GREEN MANURES

Tie a piece of muslin over one end of each of three lamp chimneys. Fill one with loam. Fill another two-thirds full of loam, then add a two-inch layer of manure and fill to the top with loam. Fill the remaining chimney two-thirds full of loam, then add a two-inch layer of grass or other green material and fill to the top with loam.

Place the chimneys in an inch of water and note the rise of moisture. Can you see any reason why seeds should not be planted a short time after turning under green manure? Why?

EXERCISE 30

EFFECT OF DIFFERENT PLANT FOODS

Fill seven 8-inch flower pots with sand. Number and label the pots. Add plant foods as follows:

1. Nothing.
2. 10 grams of lime.
3. 10 grams of lime, 1 gram of potassium chloride.
4. 10 grams of lime, 1 gram of acid phosphate.
5. 10 grams of lime, 1 gram of sodium nitrate.
6. 10 grams of lime, 1 gram of potassium chloride, 1 gram of acid phosphate, 1 gram of sodium nitrate.
7. About one pint of stable manure.

Mix the materials in each pot and then plant five kernels of wheat in each pot. Record the growth of the plants from day to day, noting the amount of growth and the color.

EXERCISE 31

CROP ROTATION

Reasons for crop rotation: (1) different crops remove different amounts of plant food; (2) crops feed at different depths; (3) economy of labor; (4) failure of one crop will not mean entire failure; (5) improvement of the soil.

Factors to be considered: (1) in four-year rotation the farm must be divided into four equal parts, in three-year rotation, into three equal parts, etc.; (2) the money crop; (3) animals to be fed.

Fill out the blanks below, indicating crops adapted to your state to make a four-year rotation.

Field				
1				
2				
3				
4				

Plan a rotation for a 150-acre farm that will produce 50 acres of cotton, 50 acres of corn, 50 acres of oats, and 100 acres of cowpeas.

Field			
1			
2			
3			

EXERCISE 32

PLANT FOOD REMOVED BY CROPS

If an acre of corn, yielding 40 bushels, removes 35 pounds of nitrogen, 15 pounds of phosphorus, and 12 pounds of potash, how many pounds of nitrate of soda (16 per cent), acid phosphate (16 per cent), and muriate of potash (50 per cent) will it take to supply the plant food removed?

What is the difference in the value of the plant food removed by 100 acres of corn, yielding 40 bushels per acre, and the market price of the corn?

Nitrogen is worth 17 cents per pound, phosphorus 5 cents per pound, and potassium 5 cents per pound.

EXERCISE 33

TILLAGE IMPLEMENTS

Make a list of the different kinds of plows and discuss the usefulness of each. In the same manner list the different kinds of harrows, of cultivators, and of rollers, and discuss the usefulness of the several kinds of each implement.

EXERCISE 35

COMMERCIAL FERTILIZERS

1. Assuming that nitrogen is worth 17 cents per pound, phosphorus 5 cents per pound, and potassium 5 cents per pound, calculate the commercial value of the plant food in a ton of fertilizer with the following composition: (*a*) 10–2–2*; (*b*) 8–3–2; (*c*) 5–4–5.

2. Calculate the percentage of nitrogen, phosphorus, and potassium in a mixture of

600 pounds of nitrate of soda (15 per cent)
1000 pounds of acid phosphate (16 per cent)
400 pounds of kainit (12 per cent)

3. How many pounds of each of the materials used in 2 would it take to make a ton of fertilizer analyzing 8–2–3?

NOTE. Problem 3 is one of compound proportion. The per cent of plant food in a given material is to the total amount of that kind of plant food wanted in the mixture as 100 is to x. To determine the number of pounds of acid phosphate needed in this problem, we should have

$$16 : 160 \text{ (or total number of pounds in a ton)} :: 100 : x$$
$$16x = 16{,}000$$
$$x = 1000$$

* A 10–2–2 fertilizer contains 10 per cent phosphorus, 2 per cent nitrogen, and 2 per cent potassium. (In some states the order is nitrogen, phosphorus, potassium, in which case the formula 10–2–2 would mean 10 per cent nitrogen, 2 per cent phosphorus, and 2 per cent potassium.)

EXERCISE 36

COMMERCIAL FERTILIZERS (Continued)

1. How many pounds of acid phosphate (16 per cent), kainit (12 per cent), and cottonseed meal ($6\frac{1}{2}$ per cent nitrogen, 2.8 per cent phosphoric acid, 1.8 per cent potash) would it take to make a fertilizer analyzing 8–2–3? (When using materials containing more than one plant food, first find out the number of pounds needed to furnish the required amount of the plant food of which this material is primarily the carrier. Cottonseed meal is primarily a carrier of nitrogen, hence determine first the number of pounds of cottonseed meal needed to furnish the amount of nitrogen required in the mixture.)

2. Using the same materials as in problem 1, determine the number of pounds of each to make a fertilizer analyzing 9–2–2.

3. Use some of the materials mentioned in the above problems to make a small amount of 9–2–2 fertilizer; 100 grams will be a sufficient amount of the mixture.

EXERCISE 37

FERTILIZER TEST

Lay off ten plots about eighteen by twenty feet on as nearly uniform soil as possible. The plots may be larger or even smaller. Care should be taken to have the soil uniformly prepared. Put fertilizer on the plots as follows:

Plot 1, nothing.

Plot 2, nitrate of soda at the rate of 160 pounds per acre.

Plot 3, acid phosphate 300 pounds per acre.

Plot 4, muriate of potash 80 pounds per acre.

Plot 5, nitrate of soda 160 pounds per acre and acid phosphate 300 pounds per acre.

Plot 6, nitrate of soda 160 pounds per acre and muriate of potash 80 pounds per acre.

Plot 7, acid phosphate 300 pounds per acre and muriate of potash 80 pounds per acre.

Plot 8, acid phosphate 300 pounds per acre, muriate of potash 80 pounds per acre and nitrate of soda 160 pounds per acre.

Plot 9, barnyard manure at the rate of 10 tons per acre.

Plot 10, lime at the rate of one ton per acre.

Oats or some other crop that can be planted in the fall should be planted on the plots so that the results may be studied during the school term.

Notes should be made as to the effects of the different plant foods on the growth of the plants as well as on the yield.

EXERCISE 38

A HOME GARDEN

Draw a plan of a garden to supply a home with a succession of vegetables. The size of the family must of course be considered. Indicate on the plan the distance between the rows, the vegetables to be planted in each row, etc. If the garden is to fit a certain piece of ground, this space should be measured and a map of it made the basis for the garden plan.

On a farm it is important that the garden be arranged for convenience in horse cultivation. It is very desirable and would be profitable for farmers to grow a greater variety of vegetables than is now commonly grown.

EXERCISE 39

PLANTING PLANS FOR A HOME GARDEN

By using seed catalogues, determine the amount of seed, cost of seed, and time of planting for the garden planned in the previous lesson.

Also list the kind and amount of fertilizers as well as the manner of applying them. Give suggestions for the preparation of the soil.

EXERCISE 40

RECORD OF GARDEN WORK

Kind of soil _____

Operations of preparation, with dates _____

_____

Size of plot _____

Amount of fertilizer used _____

Amount of fertilizer per acre _____

Kinds of fertilizer _____

Date of planting _____

Kind of seed planted _____

Depth at which seed was planted _____

Which was planted deeper? Why? _____

_____

Date of germination _____

Time from planting to germination _____

Date of first cultivation _____

Size of plants at first cultivation _____

Date of second cultivation _____

Size of plants at second cultivation _____

Date of third cultivation _____

Size of plants at third cultivation _____

_____

Other operations or applications of fertilizer _____

_____

Date of maturity _____

Time from planting to maturity _____

Have plants been affected by diseases or insect pests? If so, what remedy was used? _____

_____