

## DEPARTMENT OF THE INTERIOR.

## BUREAU OF EDUCATION.

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PART PLAYED BY THE ROOT IN THE PRODUCTION OF A CROP.

This circular is intended for teachers who are conducting home-garden work. Its purpose is to outline lessons in root growth in order that the children may know the part roots play in the production of a crop and the soil conditions necessary for good root development.

*Work of the roots.*—The roots of the garden plants have a very important part to play in the success of the crop. Their work is to fix the plant firmly in the soil, to take in moisture and plant food, as well as to help to dissolve foods. In addition, some roots, such as radishes, beets, or turnips, store food for the future production of seeds, while others, such as sweet potatoes and dahlias, make new plants.

*How is the root adapted to do its work?*—The answer will depend upon a knowledge of how the roots grow in the soil and how they take in food and water.

## HOW DOES THE ROOT GROW IN THE SOIL?

When possible, take the children to a gully or to the bank of a stream where plant roots have been exposed by washing away of the soil. The children should be provided with sharpened sticks to remove the soil and trace out the root system. Let them determine the distance roots extend out, the depth they grow in the soil, the nearness to the surface, and the location of most of the roots.

The excursion should bring out these facts:

1. That most roots are found in mellow soil and only a few extend into the subsoil. These facts emphasize the importance of preparing the garden soil so that it will be deep, mellow, and congenial to the best root growth.
2. That roots extend laterally a long distance and within 1 inch or 2 inches of the surface. These facts explain why garden crops should have level cultivation and why hilling is not a wise garden practice.
3. That the extent of root growth depends not only upon the kind of root and the mellowness of the soil, but also upon the moisture content of the soil. Vegetable roots will not grow into free soil water. This fact makes it necessary to drain the soil so as to lower the free water sufficiently to insure good root development. (For directions for draining, see School Home-Garden Circular, No. 7.)

If an excursion is not possible, have the children expose the roots of their own garden vegetables.

Corn, beans, peas, and radish seeds may be planted against the glass of a root frame made as follows: Construct a frame that will hold in an upright position, 1 inch apart, two panes of glass each 20 inches by 15 inches. Pack

good garden soil thoroughly between the panes of glass and plant the seeds so the children can observe the growing roots. Use dark-colored cardboard to protect the roots from the light.

#### HOW IS THE ROOT ADAPTED TO TAKE IN FOOD AND MOISTURE?

Food and water can not enter through all parts of the root, but must be taken in through the root hairs, which are especially adapted for the work. In the first place they are located just back of the lengthening region of each root, and for this reason they are continually being brought into new feeding regions as the young roots penetrate the soil. In the second place their thin walls enable them to fit closely about the soil particles, and thus permit the film water which holds the food in solution to enter the root hairs in much the same way that food enters the blood from the digestive tract. At the same time carbon dioxide dissolved in cell water passes out of the root hairs into the film water and enables it to dissolve plant food. Why do seedlings wilt when transplanted?

Film water contains about as much plant food as ordinary drinking water. This is desirable, since root hairs can take in plant food only when it is in a dilute solution. It means, however, that quantities of water are needed to make a plant grow. It is estimated that the roots need to take in as much as 500 pounds of water in order that 1 pound of dry material may be produced by the plant. This should show the gardener the importance of preparing the soil so it will hold and retain sufficient moisture to produce the crops. It should also show the necessity of mixing commercial fertilizer thoroughly into the soil so that the film water may dissolve the fertilizer into a dilute solution. It should again show that commercial fertilizers (for example, bone meal), which dissolve slowly and provide calcium phosphorus foods for several years, need not be applied every year. What precautions should be taken so the yield of garden crops will not be decreased by a long, dry period during the growing season?

The root is also admirably adapted to penetrate the soil to absorb food. In the first place, the apex is pointed. In the second place, it is protected with a cap which is continually being built up from the inside as the friction with the soil wears away the outside. In the third place, the cells of the root tip enable the root to avoid obstacles and grow around rocks and stones.

The following classroom experiments illustrating details of root growth would lead to a keener appreciation of this subject by the pupils engaged in this work:

Use germinating radish seeds to show root hairs. Observe that the older ones farthest from the tip are dying.

To show that the lengthening region of roots is between the tip and the zone of root hairs, place marks with India ink one-eighth inch apart on the roots of germinating corn.

To show osmosis, tie a piece of bladder over a medicine vial partly filled with salt water. Put slices of potato in a dish of fresh water. Put others in a dish of salt water. Note results.

To show the importance of mixing fertilizer thoroughly through the soil, place some young lettuce plants in a bottle containing a dilute solution of nitrate of soda. Place some others in a strong solution. Note results.

To show how transplanting causes the root systems of seedlings to form in a close cluster, use a sharp knife and remove the tips of some healthy growing roots of germinating corn. In two or three days compare these root systems with those that have not been disturbed.

## HOW SHOULD THE KNOWLEDGE OF ROOT GROWTH HELP THE GARDENER?

1. Knowledge of root growth shows the importance of a thorough preparation of the soil before the crops are planted in order that the roots may penetrate readily and take in sufficient food to insure a continuous growth of the plant.

2. It shows why fertilizer should be thoroughly mixed through the soil so it can be dissolved by the film moisture and absorbed by the root hairs. It also suggests the danger of putting fertilizer directly under a plant.

3. It emphasizes the part soil water plays in the yield of a crop and the significance of early preparation of the garden soil to retain soil water. It also indicates the value of frequent hoeing of the garden crops to preserve a dust mulch to prevent water reaching the surface, evaporating, and becoming lost to the growing crop.

4. It explains why cultivation is to be practiced for all fibrous-rooted crops, and why hilling may be necessary for fleshy-rooted crops when they are grown in a heavy clay soil. An exception is in the cultivation of sweet potatoes. Here hilling is advisable in all soils in order that the potatoes may develop in a ridge and for this reason meet with less soil resistance.

5. Knowledge of root growth also illustrates why the best time to transplant is in the evening or just before a rain; why tops should be pruned to balance the roots in transplanting all plants; why several transplantings of seedlings make the final placing in the garden a safe process.

6. It reveals the fact that, while fine fibrous roots of the grasses can penetrate a close soil-like clay, the tap roots of the garden vegetables require a light loamy soil.

7. It shows why as soon as the roots of house plants fill a pot, the plant should be removed, the outer roots cut away, and the plant placed in a larger pot with new soil.

8. Knowledge of root growth also makes it clear that roots can not do their work if they are attacked by enemies, such as slime mold, which causes club root of cabbage and other members of the mustard family; nematode worms, which cause swellings on the roots of lettuce, tomatoes, and cucumbers; and insects, which not only injure the roots, but permit the entrance of destructive bacteria and fungi.

There are various ways the gardner can protect the roots of the garden plants:

1. By securing healthy plants and placing them in healthy soil.

2. By planting the crop in other sections of the garden in case of severe attacks.

3. By taking precautions not to transfer infected soil to other sections of the garden.

4. By discontinuing the growing of a crop for a number of years.

(For topics covered in paragraphs 1 and 5, see School-Home Garden Circulars, Nos. 6, 7, and 9.)

## WHAT ARE THE CONDITIONS NECESSARY FOR ROOT GROWTH THAT CAN BE PROVIDED BY THE GARDENER?

1. A deep mellow soil in order that the roots may penetrate easily and that the rain may enter and be retained.

2. A warm soil in order that more plant food may be dissolved and that osmotic force may be more active. On nights when the soil temperature falls below 55 degrees, pumpkin and tobacco leaves wilt because osmotic action is

so slow in the root hairs that sufficient water is not absorbed to supply even the small amount that is transpired from the leaves.

3. A soil with a certain amount of air to provide for respiration in the roots and to help dissolve plant food.

4. An abundance of plant food in order that the vegetables may grow more rapidly.

(For directions how to make the garden soil deep, mellow, moist, with sufficient heat, air, and plant food, see School-Home Garden Circular No. 7.)