

A MICROSCOPIC EXAMINATION OF CERTAIN DRINKING WATERS. BY GEORGE
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THE EFFECTS OF DROUGHT UPON CERTAIN PLANTS.—AN EXPERIMENTAL STUDY.
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Because of the general knowledge of the subject, and the great influence of drought upon the economics of agriculturists and manufacturers, the following experiments were undertaken.

The purpose of this paper is to show by results of experiments the effects of drought not only upon the general appearance of the plants studied, but more especially upon the different tissues.

The plants used for observation were grown under conditions favorable to normal and healthy growth for three or four weeks or until the plants were large enough to use for experiments; then removed and subjected to drought.

The simple apparatus used to give the favorable conditions in air and soil, consisted, first, of a large glass box 3 ft. long, 2 ft. wide, and 1½ ft. deep, and fitted with a glass cover; second, a number of Erlenmeyer flasks fitted with perforated stoppers holding long glass tubes. These flasks were filled with water and inverted so that the glass tubes dipped into shallow pans containing the plants in flower pots.

The plants used in the experiments were *Oxalis*, *Canna*, corn, common bean, Castor bean and cucumber. In making the drawings the camera lucida was used.

Two *Oxalis* plants were taken from the green house. These plants were of equal size and uniform appearance. One of these plants was examined immediately, and one was placed in the dry air of the laboratory and a minimum amount of moisture supplied to the roots.

Comparing the two plants as regards general appearance, I noticed that the oldest leaves of the plant subjected to drought soon grew yellow and dropped off. The leaves just budding when brought into drought grew very slowly, and did not expand properly, and presented a peculiarly twisted or folded surface. After being subjected to drought five weeks the leaf stalks had grown in length only three inches, were of an intense dark green color, and somewhat stiffened or woody. Leaves of plants subjected to drought also showed a tendency to earlier acquire the xanthophyll than those of plants under normal conditions. The effect

of drought on the trichomes caused the plant to become exceedingly viscous, giving the plant a glistening appearance. Another effect of drought on the general appearance of the plant was the prevention of the opening of the flower buds, which soon withered.

In the case of the plant kept under normal conditions for the same length of time the leaves expanded perfectly, the leaf stalks were much elongated and quite flexible. The plant was of lighter green color, and in general did not show the dwarfed appearance of plants subjected to drought.

When examined with a microscope the different tissues are found to show as marked differences as the general appearance of the plants.

When we compare two strips of epidermis, one taken from the lower surface of the leaf of the plant grown under normal conditions and one from a plant subjected to drought; the first difference noticed is that of the turgescence of the plant cells.

The cells of the plants grown under normal conditions are very large and turgescient.

The cells of plants subjected to drought lack turgescence, and show a weak, flaccid cell wall, are also much smaller than these under influence of moisture. The growth of the cells being retarded, the stomata are brought nearer to each other so that the number per inch is 1400, while the number under normal conditions is only 400 per inch.

Drought also causes a slight change in the guard cells, producing a corresponding change in the breadth of the stomata.

See figures I and II.

The trichomes of *Oxalis* are numerous and are of the glandular variety. Their distribution over the surface of the leaf corresponds to that of the stomata. On the epidermis of plants subjected to drought the trichomes are more numerous than those of plants grown under moist conditions; are also shorter and more globular.

The cells of normal plants contain an abundance of starch; under the influence of drought this starch is greatly diminished.

The *Canna* was the next plant observed, and was if possible more changed by drought as regards manner of growth than the *Oxalis*. The plant was only subjected to drought for three weeks, but in that short time the growth was considerably retarded.

When the seeds of the *Canna* are allowed to germinate under conditions of drought, the plantlets grow very slowly, sending out numerous opposite leaves. When the plants were removed to good conditions for growth, they refused for

several weeks to grow; then above the stunted portion strong leaf stalks shot upward, and in three weeks had attained a height twice as great as the stunted portion had reached in two months. The leaves of plants grown under normal conditions were alternate.

The effect of drought on the *Canna* was not as immediate as in case of the *Oxalis*, not causing wilting, but in time became more decided because of the changed position of the leaves.

The structural differences were quite apparent. In a strip of epidermis taken from the leaf of a normal plant the cells were irregular and angular; the angles were held firmly in position by the turgescence. The guard cells showed a firm outline. The stomal openings were quite narrow. The stomata were slightly more numerous under drought, being 600 per inch, in normal plants 400 per inch. The stomata openings were also wider in drought. See figures 3 and 4.

The common bean will apparently withstand more drought than any of the plants examined. The general appearance of the plant was not materially changed. The growth, however, was retarded by drought, the stalk only growing half as long as the stalk of normal plant in the same length of time. The shorter stalk was also larger in diameter. The plant grown under favorable conditions was more flexible, not because of lack of turgescence, but because of lack of thicker cell walls developed by drought.

The plant cells were smaller and less turgescient when subjected to drought. The stomata were increased in number, the guard cells metamorphosed, and the stomal openings larger than those of plants grown in moisture.

The trichomes of the bean are not branched, and are of the non-glandular variety. When subjected to drought they remain shorter, and the diameter is increased slightly.

In a cross section of the stem of plants subjected to drought, the non-turgescence of the cells was shown, also a slight thickening of the cell walls. This thickening was demonstrated by the time required for the iodine to penetrate the cell walls as compared with the walls of cells grown in favorable conditions. See figures 5 and 6.

The general appearance of corn showed the effects of drought more in change of color and the tendency of the leaves to twist and wrinkle lengthwise. The growth was also stunted.

The epidermis was more difficult to separate from the underlying tissue of plants subjected to drought than from plants under normal conditions. The characteristic difference in turgescence of the cells was shown, also metamorphosed guard cells and stomata. See drawings, plates 7 and 8.

The Castor bean can withstand the least amount of drought of any of the plants observed. After being subjected to drought for one week, there was a decided change in general appearance. The leaves wilted and shrivelled, and the stalk was not turgescient enough to remain erect, but wilted. It was almost impossible to obtain the epidermis from the leaf because of its clinging to the underlying tissue. By referring to the accompanying drawings of the Castor bean (Plate 9) the differences in structure of the plants grown under the different conditions may be seen. The stomatal guard cells and the surrounding tissue cells are seen to be smaller in plants subjected to drought. The stomata are increased in number from 500 per inch in moist air to 700 per inch in drought.

A cross section of the stem showed the characteristic difference in turgidity and size of the cells.

The effect of drought on the cucumber in general is to destroy the turgescence and give the stem a wilted appearance. The number of stomata are increased in drought, as seen in figure 10.

From the above experiments it may be seen that immature plants subjected to drought for only a short time have decided changes in general appearance and structure. It seems very probable that in different plants such changes might occur, as a result of drought, as would greatly change not only the habits of the plant but its life history.

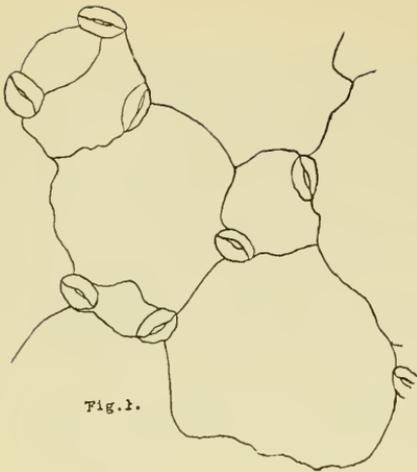


Fig.1.

Epidermis, leaf of Oxalis
Grown under normal conditions.

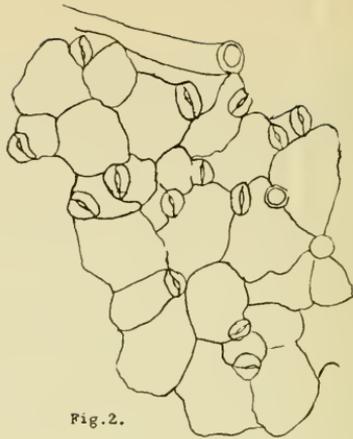


Fig.2.

Epidermis from Oxalis
subjected to drought.

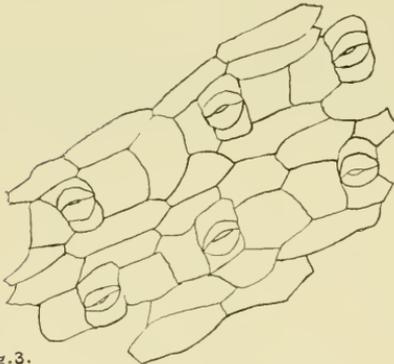


Fig.3.

Epidermis, leaf of Canna,
grown under normal conditions.

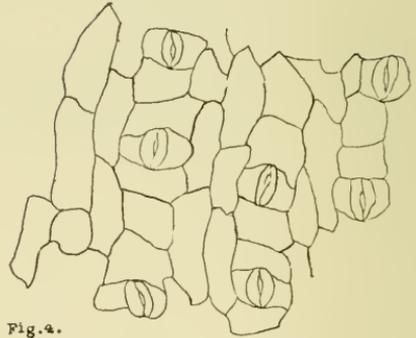


Fig.4.

Epidermis, leaf of Canna,
subjected to drought.



Fig.5.

Epidermis leaf of common bean,
grown under normal conditions.



Fig.6.

Epidermis, leaf of common bean,
plant subjected to drought.

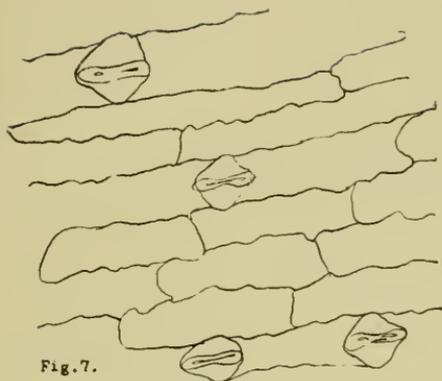


Fig.7.

Epidermis, Corn grown under normal conditions showing turgescient cells.

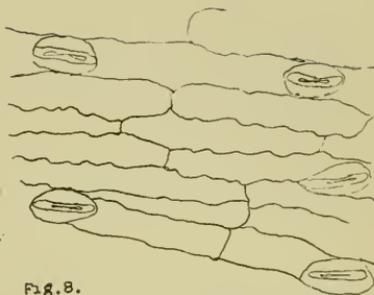


Fig.8.

Epidermis, blade of corn, subjected to drought

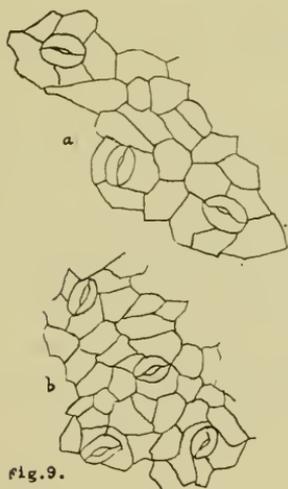


Fig.9.

Epidermis Castor bean.
a-Under normal conditions.
b-Subjected to drought.

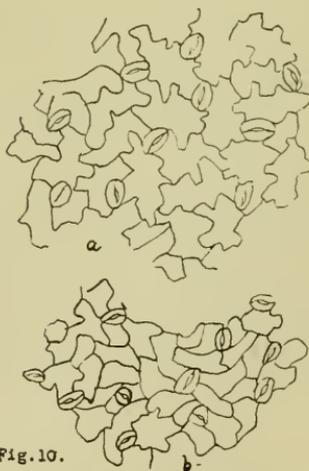


Fig.10.

Epidermis of Cucumber.
a-Under normal conditions.
b-Subjected to drought.