STRUCTURAL CHANGES PRODUCED IN LEAF TISSUE OF SOY BEAN PLANTS BY IRRADIATION OF THE DRY SEEDS WITH SOFT X-RAYS

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(WITH EIGHT FIGURES)

Introduction

In a recent paper NOGUCHI (2) described histological studies made on the structure of Russian sunflower leaves grown from seeds irradiated at the stage of incipient germination, with hard, or short wave-length, x-rays. This paper describes a similar study in which the seeds used were dormant soy beans and the radiation was soft, or long wave-length, x-rays generated by a gas x-ray tube (1). Although it is not the purpose of this paper to compare the two types of radiation with regard to their ability to produce deformed plants from irradiated seeds it may be said that if a given quantity of radiant energy in the x-ray region here considered should strike the surface of a seed, a greater part of it would be absorbed by the seed if the radiation were of long wave-length than if it were of short wave-length. If the extent of the deformity produced in the plants grown from x-irradiated seeds depends on the quantity of energy they have absorbed, then one would expect the longer wave-length to produce the greater deformity, if the incident quantities of energy were alike.

Method

Wilson black soy bean seeds which had been stored under ordinary conditions of temperature and humidity for about a year were used. They had therefore acquired the moisture content normally associated with dormant seeds. These were placed 8 cm. from the focal spot of the x-ray tube and were irradiated for periods from 10 to 80 minutes with the x-rays from the tube mentioned, when it was operated at 20 peak kv. and 10 m.a. Under these conditions the shortest wave-length in the beam of x-rays was about 0.6 Å, while the most intense part of the beam was the Kα line of copper (1.54 Å). The beans were then planted in ordinary soil in a greenhouse, together with unirradiated ones for controls. The irradiated seeds produced deformed plants, of which figure 1 is an example, while the unirradiated seeds produced normal plants. Those which were irradiated for the longer periods of time produced plants exhibiting similar deformities to a greater degree.

Results

After an examination of the outward appearance as well as the corresponding sections of a large number of deformed leaves, it was found that almost all of them fell into one of the following classes:
1. Normal leaf (fig. 2). The epidermal cells are of uniform rectangular shape and form a fairly smooth leaf surface. The palisade layer is composed in most cases of two layers of cells placed evenly and having only a small amount of space around each cell. The chloroplasts are arranged just inside the cell wall and are spaced evenly. In the spongy parenchyma layer the cells show an irregular pattern in cross-section and have the chloroplasts arranged irregularly. The spongy tissue extends all the way to the epidermis.
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2. Leaf with numerous small light spots (fig. 3). These spotted areas are caused by the failure of the upper layer of palisade cells to develop.

Fig. 2. Normal leaf.

Fig. 3. Leaf with numerous small white spots.
normally and produce chloroplasts, so that these areas are light in color. Sometimes the second layer of palisade cells is also affected. Neither the epidermis nor the spongy tissue is noticeably changed.

3. Leaf with large light-grey areas, found mainly on the second and third sets of leaves (fig. 4). In this case the palisade cells appear to be normal but are spaced farther apart. In some leaves there are fewer than the normal number of chloroplasts in the cells. The chloroplasts in the cells of the spongy parenchyma layer are arranged irregularly, sometimes clumped together.

4. Leaf with small dark-green areas which appear normal except for color (fig. 5). (The dark-green areas are difficult to show in photographs of the leaves.) This injured condition seems to be due to an unusually large number of chloroplasts containing an excessive amount of chlorophyll in both the palisade cells and in the spongy tissue.

5. Leaf with large dark-green areas often raised and crinkled (fig. 6). In this kind of tissue the palisade cells are closely packed together and the cells seem to have more than the usual number of chloroplasts. The palisade
Fig. 5. Leaf with small dark-green areas.

cells are usually somewhat elongated and extend into the spaces belonging to the spongy parenchyma. The spongy tissues are smaller in volume, and the cells adjacent to the lower epidermis are often arranged as a layer of short palisade cells containing many chloroplasts. The epidermis, especially the upper layer, is usually irregular with more rounded and otherwise oddly shaped cells. The leaves from which these sections were made received illumination from above, while growing, just as those exhibiting the other types of deformity. In both types 4 and 5, some of the cells contain chloro-

Fig. 6. Leaf with large dark-green areas.
plasts which are of a dark blue-green color suggesting a possible abnormal percentage of chlorophyll ‘a’ and ‘b.’

6. Leaves with white areas, either albino patches on the green leaf, or an entirely white leaf (fig. 7). In the albino leaves the palisade cells are entirely absent in the specimen examined. Only one plant exhibiting marked albino characteristics was grown (fig. 8). It grew from seed which had been irradiated 10 minutes at 35 peak kv. and 20 m.a., placed 30 cm. from the focal spot. The albino characteristics may have been due to factors other than the x-irradiation but sections of its leaves are interesting when compared with the types of injury which can be produced at will. The spongy tissue seemed normal except for the absence of almost all the chloroplasts, while those present contained little or no chlorophyll. The epidermis was composed of rounded and oddly shaped cells. The veins were abnormally near each other and stood out as ridges. The intervascular part of the leaf was about 60µ thick compared with about 160µ for a normal leaf. The tissues were very difficult to stain and photograph.

7. Leaf with areas completely absent. (Several examples are shown in fig. 1.)

The authors wish to thank Dr. J. Hobart Hoskins, and Dr. F. M. Turrell of the Botany Department for their interest and assistance.

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Fig. 8. Plant showing marked albino characteristics.

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