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A QUALITATIVE STUDY OF THE EFFECT OF SOFT X-RAYS ON THE ACTIVITY OF B-INDOLYL ACETIC ACID AS A GROWTH SUBSTANCE

F. M. TURRELL AND HAROLD KERSTEN

Long and Kersten (1936) found small doses of soft X-rays (long wave length) stimulate the growth of plants from seeds. Moore and Haskins (1933) observed retardation of growth of plants grown from seed irradiated with X-rays from the Coolidge tube which emanates a large proportion of hard X-rays (short wave length). Skoog (1935) has shown that 92 per cent (1000 units per cc.) hetero-auxin (B-indolyl acetic acid) in water is inactivated by hard X-rays filtered through lead, steel, and aluminum filters after exposure of 100 minutes, when the X-ray tube was operated at 3-4 milliamperes at 900 kilovolts. This raises the question as to whether "hetero-auxin" which is inactivated by hard X-rays is also inactivated by soft X-rays.

The authors express their appreciation to Dr. L. C. Bauguess for the hetero-auxin which he kindly supplied for the purposes of this study.

METHODS AND MATERIALS

The authors have studied the effect of soft X-rays from a gas tube using a copper target as described by Kersten (1934) on hetero-auxin (B-indole acetic acid). The tube was operated at 38 kilovolts and 20 microamperes at a distance of 3.3 cm from the focal point of the X-ray tube. The K_{α} (1.54 Å) line was approximately 3.5 times as intense as any other portion of the spectrum except the K_{β} line (1.38 Å) of copper which was approximately 1.3 times the intensity of any other rays except K_{α} . The minimum wave length emitted was not less than 0.35 Å.

Hetero-auxin was weighed out into ground glass deep-well slides. A cover glass was sealed over the material with a small amount of paraffin, and the dry material irradiated. A weighed quantity of lanolin was mixed with the irradiated hetero-auxin. Coleoptiles of *Avena sativa* grown on moist filter paper in large covered dishes were treated with the mixture. The authors wish to express their appreciation to Mr. L. C. Burnett, Iowa State College for supplying seed of the pure strain of *Avena sativa* (Iowa No. 2017, rustless) for this study. All tests were carried out in a

constant temperature room at 78° F. under red light. At the time the tests were made, the atmosphere in the covered dishes was approximately 100 per cent relative humidity. Ten coleoptiles were used to test the activity of the X-irradiated hetero-auxin in lanolin and ten were used to test non-irradiated hetero-auxin in lanolin. Concentration of the hetero-auxin (irradiated and non-irradiated) was equal for a given trial. A small quantity of the lanolin paste mixture was placed on the coleoptile with a finely drawn glass rod.

RESULTS

Reference to table 1 shows that heteroauxin in the dry condition irradiated with soft X-rays was not inactivated by exposures

Qualitative effect of soft X-rays on heteroauxin irradiated while dry.

| Experiment number | Length of irradiation period in minutes | Concentration of heteroauxin in lanolin paste g. per g. | | Curvature four hours after treatment | |
|-------------------|---|---|---------|--------------------------------------|---------|
| | | Irradiated | Control | Irradiated | Control |
| 5 | 0 | — | 0.0004 | — | + |
| 5 | 0 | — | 0.0000 | — | — |
| 1 | 0 | — | 0.0000 | — | — |
| 1 | 15 | ? | ? | + | + |
| 4 | 30 | 0.0002 | 0.0001 | + | + |
| 2 | 60 | 0.0366 | 0.0931 | + | + |
| 3 | 60 | 0.0054 | 0.0085 | + | + |
| 1 | 120 | ? | ? | + | + |
| 2 | 180 | 0.1937 | 0.0931 | + | + |
| 3 | 180 | 0.0251 | 0.0085 | + | + |
| 2 | 300 | 0.0308 | 0.0931 | + | + |
| 3 | 300 | 0.0028 | 0.0085 | + | + |
| 4 | 360 | 0.0001 | 0.0009 | + | + |

ranging from 60 to 360 minutes. Figures 1 to 13 show coleoptiles treated with X-irradiated heteroauxin (dry) in lanolin in various concentrations and for various periods of X-ray treatment. The bending or curling of the coleoptiles indicates that the heteroauxin was still active as a growth substance after irradiation.

Distilled water was added to a weighed portion of heteroauxin in deep well slides, and the heteroauxin allowed to go completely into solution. These were then covered with cover slips which were attached with paraffin. As irradiation progressed, the water evaporated until the material became dry. It was then mixed with lanolin and applied to the Avena coleoptiles.

In table 2 results of irradiation of heteroauxin in rather concentrated water solution show that the growth substance thus prepared was not inactivated by exposures of 30 and 138 minutes (fig. 14 and 15).

Qualitative effect of soft X-rays on heteroauxin irradiated in distilled water solution.

| Length of irradiation period in minutes | Negative curvature Control | four hours after treatment Irradiated |
|---|----------------------------|---------------------------------------|
| 30 | + | + |
| 138 | + | + |

DISCUSSION

Skoog found that hard X-rays caused the oxidation of auxin and heteroauxin both in the green plant and in vitro. Although irradiation of dry hetero-auxin was not undertaken in his experiments, he protected these growth substances from oxidation when in water solution with nitrogen and chloroform and showed that X-irradiation under these conditions was much slower than in air, or in the absence of air. A 40-minute exposure almost completely inactivated the growth substance under the latter conditions.

Using soft X-rays the writers found in a qualitative way that the activity of hetero-auxin was not greatly diminished as indicated by the curvature of *Avena* coleoptiles when hetero-auxin was irradiated in the dry condition or in small quantities of distilled water.

CONCLUSIONS

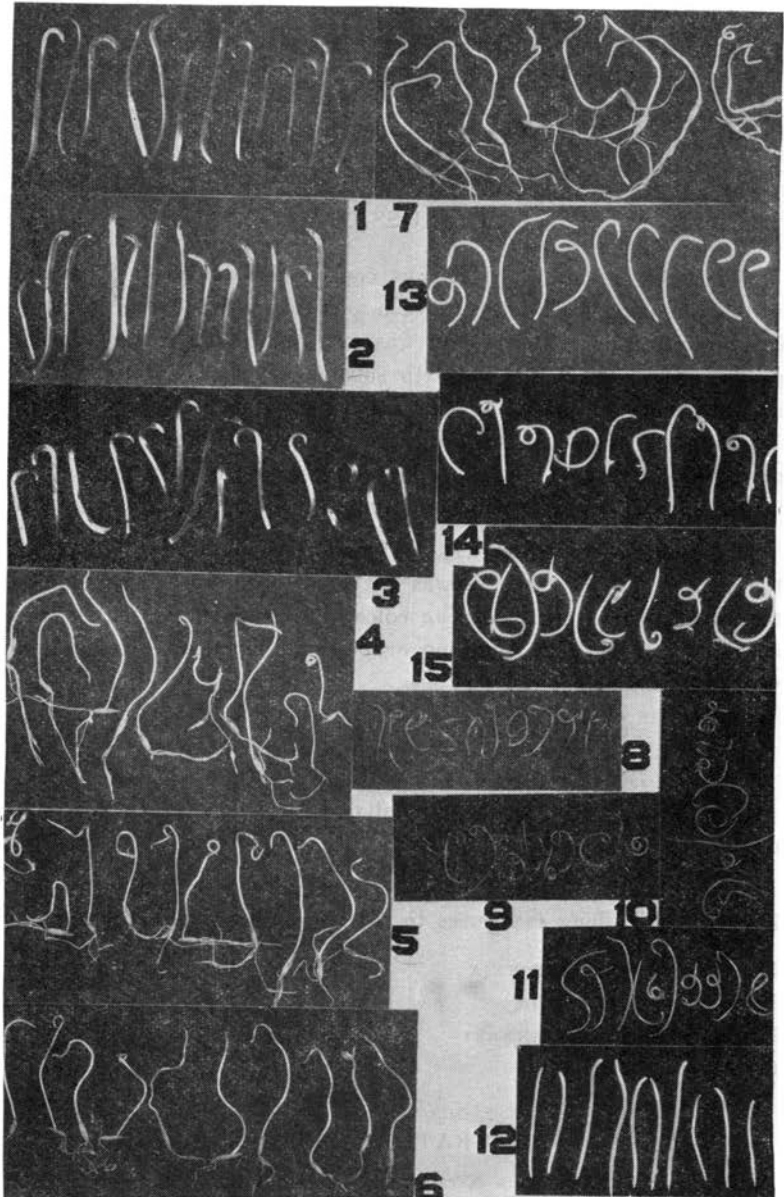
Dry hetero-auxin when irradiated with soft X-rays for 300 minutes is not inactivated.

Hetero-auxin dissolved in water in high concentration is not inactivated by long exposures to soft X-rays.

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EXPLANATION OF FIGURES

Avena coleoptiles treated with soft X-ray irradiated and non-irradiated B-indolyl acetic acid mixed with lanolin. Photographed 2 to 4 hours after treatment. Photographs for any one experiment are comparable.

- Fig. 1 Irradiated dry for 2 hours, experiment 1.
- Fig. 2 Irradiated dry for 15 minutes, experiment 1.

- Fig. 3 Not irradiated, experiment 1.
Fig. 4 Irradiated dry for 1 hour, experiment 3.
Fig. 5 Irradiated dry for 3 hours, experiment 3.
Fig. 6 Irradiated dry for 5 hours, experiment 3.
Fig. 7 Not irradiated, experiment 3.
Fig. 8 Irradiated dry for 30 minutes, experiment 4.
Fig. 9 Irradiated dry for 6 hours, experiment 4.
Fig. 10 Not irradiated, experiment 4.
Fig. 11 Not irradiated, experiment 4.
Fig. 12 Lanolin only applied (no B-indolyl acetic acid added),
experiment 5.
Fig. 13 Not irradiated, experiment 5.
Fig. 14 Irradiated in distilled water 2 hours, 18 minutes, ex-
periment 6.
Fig. 15 Not irradiated, experiment 6.