Biochemical Aspects of the Plant Injury Caused by Ionizing Radiations

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Experiments have been performed in order to elucidate the effects of different factors on the lethalizing and growth inhibiting action of X-rays (175 kV, unfiltered radiation) and fast neutrons (about 3 MeV, obtained from a Be(dn)B reaction, the deuterons being accelerated to about 7 MeV in the 80 cm cyclotron of the *Nobel Institute for Physics*, Stockholm). The neutron doses were measured by the chemical dosimetry using the oxidation of ferrous iron [1]. Dry dormant as well as pre-soaked germinating seeds of barley have been subject to investigation. Experimental data will be published elsewhere [2].

When dormant seeds are irradiated with X-rays in the presence of sulfhydryl compounds (hydrogen sulphide or mercaptoacetic acid), or at the temperature of liquid air, a protection against the radiation damage is obtained. This indicates that the damage is partly due to indirect radiation effects, which owing to the low water content in the embryo (about 10 per cent) are probably different from those normally occurring in waterous tissue (embryos of germinating seeds contain about 70 per cent of water).

Germinating seeds are 6—7 times more sensitive than dormant ones to X-rays. This difference is not simply due to the difference in water content mentioned, since the protective action of anesthetics, *e.g.* magnesium chloride and propene, is independent of the water content. In dormant seeds, too, anesthetics exert some protection. Ether given in high, anesthetizing concentrations protects against radiation, whereas low concentrations, which stimulate germination or growth, at least under certain conditions, increase the radiation damage. Temperatures deviating from those giving optimal growth (20—30° C.) decrease the radiation sensitivity. These facts indicate an influence of the physiological state (chiefly factors associated with metabolic rate and irritability) on the sensitivity of the seeds to X-rays.

In germinating seeds an increase of the oxygen pressure within the range of 0—760 mm strongly affects the X-ray sensiti-

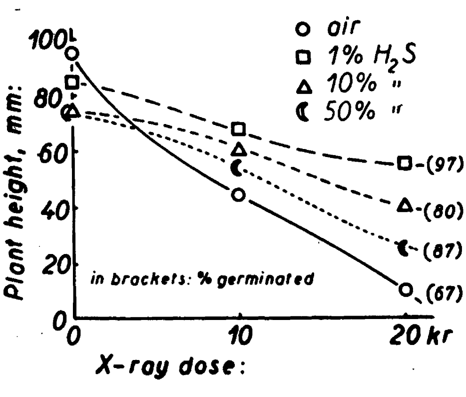

Fig. 1.

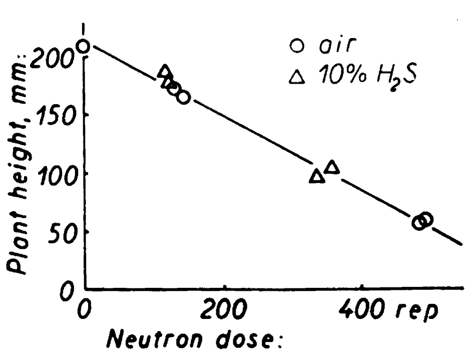

Fig. 2.

vity. The effect of oxygen may be due to: (a) a participation of O_2 in X-ray induced chemical reactions (if so, indicating an indirect effect of the radiation) or (b) an alteration of the metabolic rate *per se*. Probably both effects must be considered. Dormant seeds are much less sensitive to a change in the oxygen pressure, probably due to the very small and slow alteration of the metabolic rate. Other possibilities which have to be considered are however: a slow penetration of oxygen into or out of the dry seeds, or the absence of participation of oxygen in the chemical reactions induced in dormant seeds.

Seeds are 20—30 times more sensitive to fast neutrons than to X-rays, when equal doses are given. The difference between the radiation sensitivities to neutrons of dormant and germinating seeds is 2—3 times less than the corresponding difference in the case of X-rays. Hydrogen sulphide does not seem to protect against radiation damage caused by fast neutrons (compare Figs. 1 and 2 which show the effects of X-rays and neutrons, respectively, on the growth rate of hydrogen sulphide treated plants). Since, further, the oxygen pressure exerts a much smaller, if any, influence on the neutron sensitivity of germinating seeds, a fundamentally different mechanism of action of neutrons compared to that of X-rays has to be supposed, *i.e.* in the case of neutron irradiation the direct action of the radiation dominates. Such direct effects cannot be influenced by chemical and physiological factors in the same way as part of the X-ray effects. The difference in behaviour is probably related to the ionization densities produced in tissue (neutrons and X-rays give about 700 and 100 ion pairs per μ respectively). The field appearance of the damage caused by the two kinds of radiation is different, too: in the case of X-rays, plants not killed at a very early stage of development, survive as a rule, eliminating cells with severely damaged nuclei (chromosomes). In the case of neutrons, on the other hand, plants often germinate and grow normally for the first few days but then suddenly die. The elimination of chromosome damaged cells is much less marked. This difference leads to a much higher sterilizing and mutagenic action of the neutrons, determined in an analysis of the mature plants.

1. Ehrenberg, L., and Nybom, N. *Hereditas* **38** (1952) 481.
2. Nybom, N., Gustafsson, Å., and Ehrenberg, L. *Botan. Notiser* **1952**, **343**.

Received November 3, 1952.

Attempted Successive Applications of the Edman Degradation to Insulin

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The Fraenkel-Conrats[1] converted insulin to its phenylthiocarbamide derivative, and effected the removal of the N-terminal amino acids as the hydantoins by heating in 0.6 to 1.2 *N* hydrochloric acid at 75°. This adaptation of the Edman degradation[2] yielded the hydantoins of glycine, phenylalanine and alanine. Subsequent reapplications of the procedure were reported to release unincreased quantities of thiohydantoins, indicating that probably the vicinal peptide links only had been broken. A further adaptation of the procedure by Ottesen and Wollenberger[3], in which the acidity was reduced to 0.1 *N*, permitted the systematic degradation of hexapeptide, with, however, one extra peptide link being split during the second round. The modified procedure has now been applied to insulin. As a result of the first application, the number of free amino

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