filled with air, relying on the closeness of the electrode spacing to obtain maximal efficiency of ion collection and minimal dependence of the reading on the energy of the neutrons. The sensitivity of a chamber depends on its collecting volume and the latter was varied somewhat by filling a variable amount of air space with insulation. In this way, readings on scale were achieved at almost all of the stations where instruments were placed. Investigation of the calibrations indicated that individual instruments varied considerably but, due to the large number of chambers and the use of statistical methods, the aggregate effect of the individual fluctuations was small. Because lowering the sensitivity by closer electrode spacing introduces serious problems, such as the need for polishing the plastic to a mirror finish, and the electrical difficulties produced by small amounts of particulate matter in the chambers, the highest dose that could be read was about 250 rep. The chambers were calibrated in the cyclotron facility. Because of their design, moderate variations in the neutron spectrum should not affect the calibration. This was tested by introducing paraffin into the neutron beam, with little effect on the calibration factors. In spite of the high voltage gradient on the insulators, leakage was not a serious problem. Soakage of the insulators presented no serious difficulty.

Gamma-ray contamination in several stations was estimated in one detonation experiment by the use of nine chambers in which the collecting electrodes were made of lead. Unfortunately, the accuracy of this method decreases rapidly as the gamma-ray component increases. Lead-lined chambers are quality dependent and the gamma-ray spectrum was not known. The calibration of the chambers against Co^{60} gamma rays was the method of choice. Some confidence can be placed in the allowance for effects which would make the observed neutron dose spuriously high. Effects which would make the readings too low cannot be as easily evaluated. In addition to these difficulties, there is some evidence that the instruments are partially sensitive to slow neutrons even though particular effort was made in the design to minimize this. In general, the readings indicated a considerable gamma ray contamination. The neutron component of the dose recorded by the polyethylene chambers is probably low, because there is some evidence that their ion collection is impaired by the glutting effect of the high momentary ionization density. Since the duration of the exposure was short, the intensity was correspondingly high. Taking all these complicating effects into account, we feel that it is highly unlikely that the ion chambers have overestimated the dose. They may conceivably have underestimated it but not by more than a factor of 2. It is not impossible that they were more accurate than we have supposed. It is anticipated that, as a result of present efforts to refine physical dosimetry of neutrons, future work will be on a much sounder basis.

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An Interesting Phenomenon Associated with Irradiation of Dry Maize Seeds[1]

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In the course of experiments conducted to determine the effect of neutron radiation from a nuclear detonation on dry maize seeds, an interesting and completely unexpected phenomenon was observed at the high-dosage levels. This phenomenon is of purely biological interest but serves to emphasize that in the field of biological dosimetry extreme care must be taken to avoid the use of complex biological effects such as growth and survival, which involve a large number of little understood physiological reactions. The observed phenomenon was simply that within a certain dose range there was an unexpected relation between dose and seedling height.

Dry corn seeds were exposed in 7-in.-thick lead hemispheres to the radiation produced by a nuclear detonation. The lead hemispheres were designed to shield the material from the gamma rays so that, in the main, only the effects of fast neutron bombardment were studied. The hemispheres also protected the seeds from temperature and shock effects. One hundred seeds were placed in each hemisphere about 9 hours prior to and recovered approximately 3 hours after the detonation. The recovered seeds were treated with a dust disinfectant, and planted in sand. Ten days after planting the seedlings were removed from the seedling bed and scored. Both the percentage of seeds which germinated and the seedling height were recorded. Germination was found to be unaffected by the radiation. Every lot of treated seeds showed over 90% germination.

The results on seedling height are shown in Fig. 1. Proceeding from the low to the high doses, the seedlings show an initial decrease in height followed by an increase as the high dose levels are approached. There are two possible conclusions which could be drawn

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[2] The author acknowledges the unselfish cooperation, during the detonation experiments, of Harold H. Plough, at that time Assistant Chief, Biology Branch, Division of Biology and Medicine of the U.S. Atomic Energy Commission.

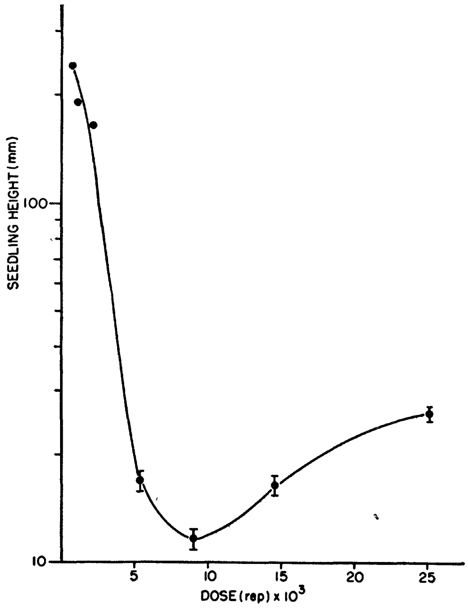

FIG. 1. Relation between seedling height and neutron dose (rep) from nuclear device test. Confidence limits are 95%.

from these data. The first is that there is a direct correlation between seedling height and neutron dose, signifying a very large error in the physical dose estimates. This would indeed be a surprising result since it would mean that the material exposed in hemispheres close to the detonation received a lower dose of radiation than did the material in the more distant hemispheres. The dosage was estimated by an extrapolation of the rep at the low dose ranges as measured by the polyethylene thimble chambers of C. W. Sheppard. The extrapolation was made to follow the slope of the sulfur neutron flux. The second possibility is that the admittedly rough physical dose estimates were not very seriously in error, thus pointing to a failure of correlation between seedling height and dose.

To distinguish between these two alternatives, similar experiments were conducted using gamma radiation from a Co^{60} source where the dose can be measured more accurately. Seeds were exposed to doses of radiation ranging from 75,000 to 500,000 r. The same phenomenon was observed in these experiments (Fig. 2). There is an increase in seedling height with increased doses above 125,000 r with the effect leveling off at 400,000 r.

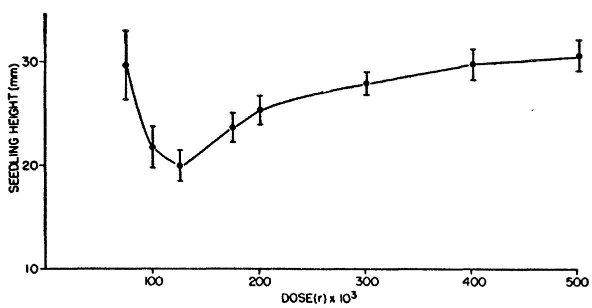

FIG. 2. Relation between seedling height and γ dose from Co^{60} source. Confidence limits are 95%.

Do these data point to a stimulatory effect of radiation on plant growth? The answer is definitely, no! Cytological examination of the root tips from plants which received high doses of radiation revealed a complete absence of cell division. In other words, the "growth" was due entirely to cell elongation in these seedlings. This was borne out by the observation that seedlings which received more than 9000 rep at the test and 125,000 r of gamma radiation from the cobalt source reached their maximum height at about 5 days after planting. No further elongation was observed for the next 5 days. The seedlings irradiated at the higher dose levels were not only taller but also much healthier in appearance than those at the lower levels. In fact, those seedlings could not be differentiated from normal unirradiated young seedlings except that there was a cessation of further growth after approximately 5 days.

The conclusion drawn from these data is that at high radiation levels the seeds are killed in the sense that no further cell divisions occur. To explain the increased "growth" made by the seedlings which received the higher doses it is postulated that the effect was due to an inactivation by high doses of radiation of those processes in the cell which are responsible for the breakdown of the plant tissue, probably the enzyme systems. Thus in the neighborhood of 125,000 r cell division is completely knocked out and the plant tissue degenerates. At higher doses both cell division and enzymatic activity are affected so that the seedling grows to its maximum height through cell elongation and for a period remains at a status quo, neither degenerating nor making more growth.

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The Production of Dominant Lethals in *Drosophila* by Fast Neutrons from Cyclotron Irradiation and Nuclear Detonations[1]

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A considerable area of disagreement exists between the relative biological effectiveness (RBE) of x-rays and fast neutrons in producing chromosome aberrations in plants and in *Drosophila*. For example, Thoday (*1*) reports that in *Tradescantia* fast neutrons are 5–10 times as effective per unit dose in producing interchanges and 3.6 and 2.4 times as effective in in-

[1] Work performed under Contract No. W7405-Eng-26 for the Atomic Energy Commission.

[2] The authors would like to acknowledge the unselfish cooperation, during the detonation experiments, of Harold H. Plough, at that time Assistant Chief, Biology Branch, Division of Biology and Medicine of the U.S. Atomic Energy Commission.