Chairman: A. D. Nutting

PROGENY TEST FROM A PITCH PINE-OAK FOREST DAMAGED BY LOW LEVEL CHRONIC GAMMA RADIATION[1]

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INTRODUCTION

Ionizing radiation is useful to plant breeders in obtaining mutations beneficial from an economic point of view. This report, however, concerns our basic knowledge of radiation: attention is here directed to some effects of low level radiation on the R_1 progeny. Approximately one third of the land area of the United States is covered by forest; thus, forest trees form an important component of our natural wealth. It is therefore our obligation to know how these forests will react to low level ionizing radiation. Although this type of radiation might accompany atomic explosions, its effects may not be evident for a number of years.

The following remarks describe the results of an investigation of a forest of Pinus rigida Mill. and Quercus sp surrounding the Cobalt 60 radiation field at the Brookhaven National Laboratory, Upton, N. Y. The pine trees used were growing in a belt receiving between approximately 2 and 4.5 r/20 hr, day during 1960-61. The oak trees used were growing in a region that received daily amounts of radiation ranging from a high of 6 to a low of 3 r/20 hr. day during 1960-61 (figure 1). The trees had been subjected to varying dosages since 1951; for a detailed schedule of the gamma radiation in this field the reader may refer to the article by Sparrow (1960).

METHODS

Cones were collected from the pines during the fall of 1961 and were kept separately according to tree and to year. Cones that had matured during 1958, 1959, 1960, and 1961 were available from some trees. The fact that pitch pine cones are serotinous permitted the collection of seed formed several years ago which had remained on the trees for periods of up to four years. The seeds were extracted and stratified before being sown in the greenhouse for progeny testing.

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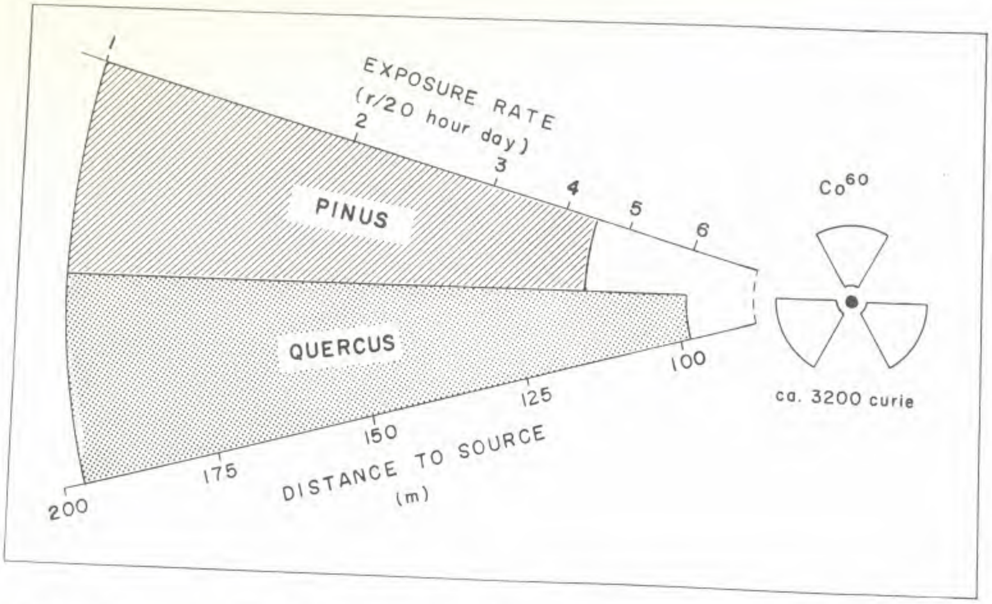

Figure 1.--Schematic illustration of the dosimetry conditions in the pine-oak forest surrounding the Gamma field at the Brookhaven National Laboratory.

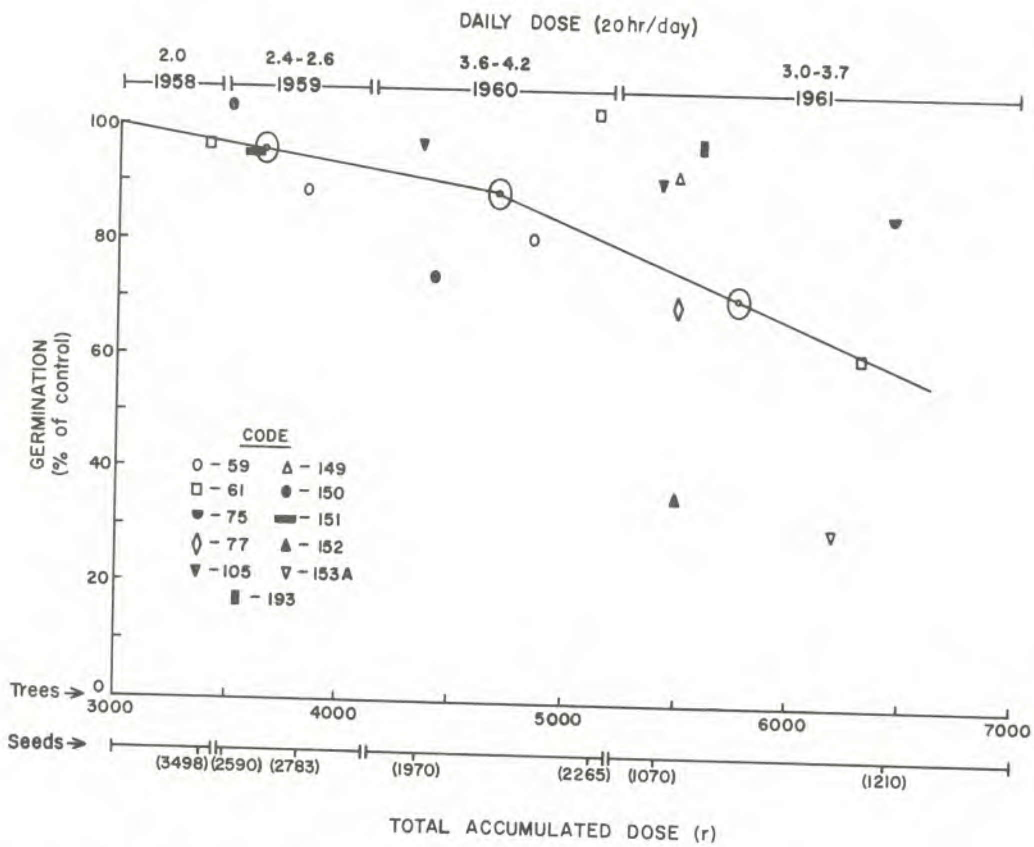

Figure 2.--Relation between germination of pitch-pine seed and exposure to radiation. The total exposure of a tree, a seed lot, as well as daily dose-rates during 1961 are indicated. ⊙ = average values for 1956, 1960, and 1961.

Acorns were available only from Quercus alba Linn. formed during 1961, and these were sown right after collection in flats filled with a germination medium consisting of peat moss and sand.

It is of interest to note that pines take approximately 26 months to pass from flower initiation to seed maturity, while white oaks take only about 12 months. This extended period in the pine allows radiation to ac cumulate for a considerably longer interval in the gametic cells or in their immediate progenitors.

RESULTS AND DISCUSSION

There was a significant decrease in the germination percentage of the seed from the pine trees exposed to gamma radiation. The results from the test, expressed as a percentage of the controls, are illustrated in figure 2. In this graph the results are separated by tree and by year. Also, the total radiation accumulated by the trees, that accumulated by a seed lot, and the average exposure for each year are given. An important conclusion of this progeny test with pine seed is that the decrease in the germination of the irradiated seed was not associated with the total radiation accumulated by a seed lot, but with the total dose to which individual female parent trees had been exposed prior to, and during seed formation. As an example, one seed lot had been exposed to approximately 2,590 roentgens without any reduction in germination.

Although there was considerable variation in germination between the seed lots of Quercus alba this variation did not parallel the amount of radiation to which the trees had been exposed. Thus the variation must have re flected other factors, perhaps genetic, physiological, or environmental. How ever, when the survival of seedlings is compared with the exposure to radiation of the mother trees, there was a significant decrease in survival that was associated with radiation. This relationship is illustrated in figure 3. The radiation values in the graph are for daily exposures during 1960-61, and also for the total exposures since the gamma field went into operation in 1951.

The height of the irradiated pine seedlings at the cotyledonary stage was compared with that of the control seedlings of the same age. There was a sig nificant reduction in the total height of the irradiated seedlings; this relationship is presented by means of a bar graph in figure 4. From this diagram it is apparent that seedlings from the seed stored in the cones for four years are considerably shorter than those stored for a shorter tins, and that the irradiated seedlings are much shorter than the controls,

It should be noted that the height values used are in effect the length of the hypocotyl and these cells were formed at a time when the embryos were exposed to ionizing radiation. The first growth in the pine seedlings was thus a result of the maturation and elongation of hypocotyl cells subjected to radiation during formation and includes physiological effects during seed formation. Thus the reduced height growth that was observed may be a somatic radiation effect rather than permanent genetic change.

In general the height growth of the oak seedlings was normal, but the seedlings from acorns of the irradiated trees grew more slowly than the controls. The progeny for trees receiving 6 roentgens per day during 1960-61 were significantly shorter than the controls (figure 5).

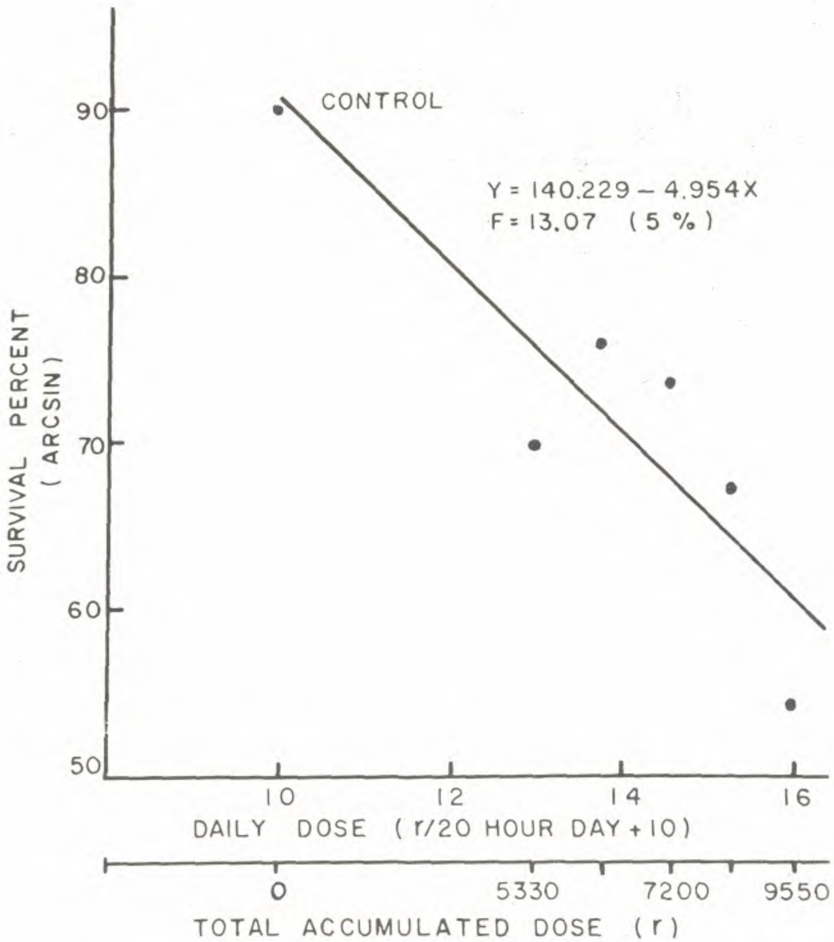

Figure 3.--Relation between survival of *Quercus alba* seedlings and exposure to radiation. The daily dose rates during 1961, as well as the total exposure of the trees are given. The values in the regression equation are for daily rates.

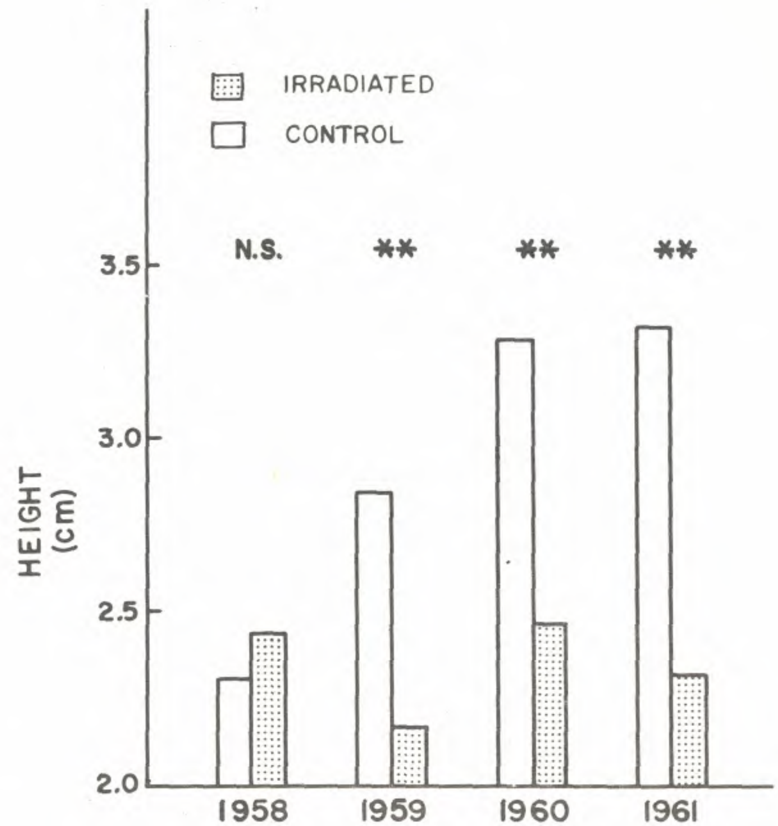

Figure 4.--Comparison of height of control and irradiated *Pinus rigida* seedlings from four collections.
N. S. = difference between means not significant at 5 percent level;
** = difference significant at 1 percent level.

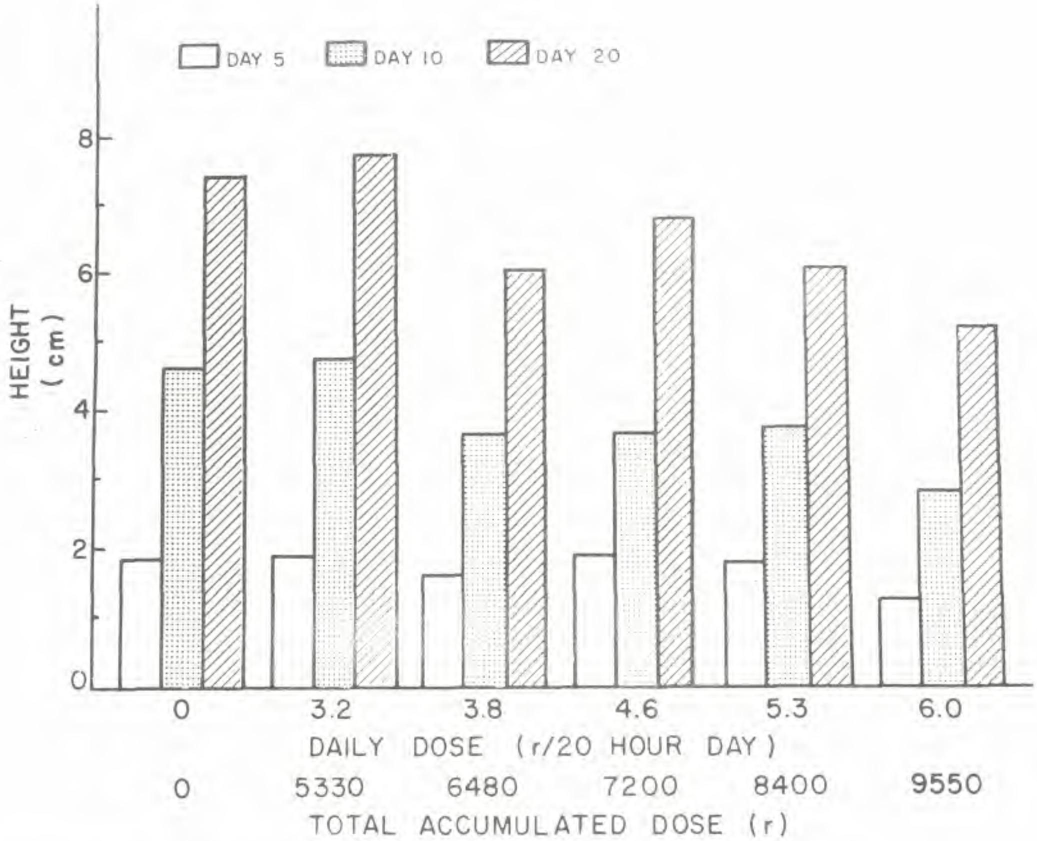

Figure 5. Height of Quercus alba seedlings, five, ten, and twenty days after germination in relation to daily dose and total radiation exposure of the oak trees.

Both the oak and pine seedlings have been outplanted in a progeny test in ur experimental nursery, and their morphology is being studied closely to detect any mutations. The pine seedlings showed considerably more variation than the oak. Within the oaks the amount of abnormalities present during the juvenile stage in the irradiated group was no greater than that obtained under normal conditions.

A comparison of the pines with the oaks shows that the pines are in general much more sensitive than the oaks. As a matter of fact, some of the pine seed was collected from trees that were dying or dead. Some of the acorns were collected from trees showing few morphological abnormalities, while some of the oaks showed sparse crowns as well as morphological abnormalities in the floral structures. Scientists at the Brookhaven National Laboratory (Sparrow and Miksche, 1961) have shown a correlation between irradiation damage in plants and nuclear volume during interphase in meristematic cells. The pines have large nuclei, which are five to ten times larger than the interphase nuclei in the oaks. The differential damages observed between the two species in this study agree with their conclusion.

Both pine and oaks are wind pollinated, and the trees under study were surrounded by forests receiving relatively little outside radiation. Hence, it was possible for non-irradiated pollen to be borne by the wind into this forest and to pollinate the trees under observation. This could have masked some of the actual damage.

From this progeny test it appears that under certain circumstances a pitch pine forest severely damaged or killed by low-level chronic radiation could regenerate itself once radiation had ceased from seed stored in serotinous cones. Oak regeneration from seed would be dependent upon the timing of exposure in relation to the current flower and seed crops

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