Proceedings of the Iowa Academy of Science

Volume 64 | Annual Issue Article 17

1957

The Relationship Between Moisture Content and X-Ray Sensitivity of Oat Seeds, Avena sativa

R. Abrams

K. J. Frey

The Relationship Between Moisture Content and X-Ray Sensitivity of Oat Seeds, *Avena sativa*[1]

By R. Abrams and K. J. Frey

About a decade ago, Gustafsson (3) reported that the sensitivity of barley seeds to x-ray treatment was positively related to their moisture content. Sensitivity was measured by germination percentage and vigor of seedlings produced from treated seeds. However, Caldecott (1) recently has shown that barley seeds with a moisture percentage between 8 and 16 were more resistant to x-ray damage than those with either a lower or higher water content. These conflicting results probably are related to differences in methods used to temper the seeds by the two investigators. Gustafsson (3) soaked the seeds in water while Caldecott (1) placed them in desicators with different relative humidities. Metabolic activity and x-ray sensitivity of seed would be expected to be enhanced more by the first method. For a discussion of the physical significance of moisture content of seeds on x-ray sensitivity the reader is referred to a paper by Caldecott (2).

This paper reports experiments conducted to determine the relationships between moisture content of seeds and x-ray sensitivity in hexaploid oats.

Materials and Methods

Seeds of *Avena sativa* var. Bonham were placed in desicators to temper them to different moisture contents. Three seed moisture levels of 5.0, 13.8, and 18.2 percent were obtained by using concentrated sulphuric acid, saturated sodium cloride solution, and distilled water, respectively. The desicators were kept at approximately 70° F. during the tempering process. The time necessary for the seed to reach an equilibrium moisture content was 14 days. The seed from each moisture level was divided into five samples; one each to be treated with 15,000, 20,000, 25,000, 30,000 and 40,000r of x-ray, respectively.

The seeds were radiated with a G. E. Maxiton x-ray machine operating at 250 kvp and 30 ma. The radiation was filtered through a 0.25 mm. Cu. + Al. filter and the dose rate was 1305r per minute.

[1]Journal Paper No. J-3189 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project 1176. In cooperation with the Crops Research Division, A.R.S., U.S.D.A. Part of a thesis submitted by the senior author to the graduate faculty in partial fulfillment of the degree of master of science.

The distance from the tube to the center of the target was approximately 15.5 centimeters. The seeds were radiated in a plastic container with 3 compartments; thus 3 lots of seed with different moisture levels were simultaneously treated with the same dosage. Within 24 hours after treatment the seeds were planted in flats in the greenhouse. A plot consisted of 100 seeds sown one-half inch deep in a sterilized mixture of loam, sand and peat in a ratio of 2:1:1. The experimental design was a randomized block with three replications and non-radiated seed, used as a check, was included four times in each replication. Germination percentages and plant heights in centimeters were determined for each plot 14 days after planting. On the same day the seedlings were cut at the soil surface, dried at 30° C. and weighed. The dry weights in grams were adjusted to weight per 100 seedlings.

Experimental Results

The germination percentages of oat seeds treated with different dosages of x-ray are presented in Figure 1. Germination percentages of seeds with 5.0 percent moisture were approximately equal for all x-ray dosage over the range from 15,000 to 40,000r units. Seed with 5.0 percent moisture was very sensitive to x-ray treatment with at least four-fifths killed at each dosage. It was necessary to apply 40,000r units of x-ray to materially reduce the germination percentage of seed with 13.8 percent moisture. Seed with 18.2 percent

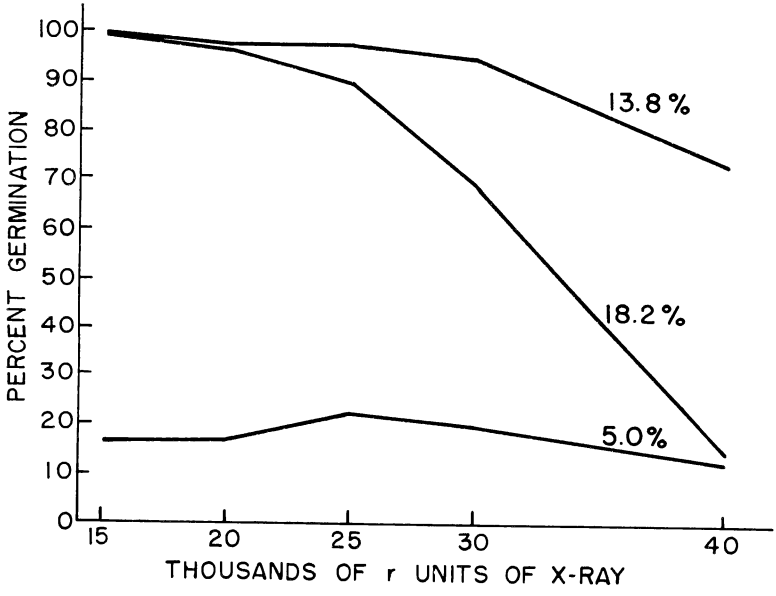

Figure 1. Germination percentages of oat seeds with varying moisture levels and treated with different dosages of x-ray.

moisture was as resistant to x-rays as seed with 13.8 with dosages of 15,000 and 20,000r, but at dosages of 25,000r or more the highest moisture seeds were much more sensitive, being as low in germination as those with 5.0 percent when 40,000r were applied.

Seedling height and dry weight per 100 seedlings for different radiation dosages and moisture levels are shown in Figures 2 and 3, respectively. Samples with 5 percent moisture were more sensitive than those at higher moisture to x-ray dosages up to 30,000r. However, at the lowest moisture level the vigor of the seedlings was nearly independent of dosage. Vigor of seedlings from seeds with the highest moisture content was less at each successive rate than those from the intermediate moisture level.

All three criteria used to measure the x-ray sensitivity of oat seeds, namely, germination percentage, seedling height and seedling weight, indicate that the order of seed moisture contents from least to greatest resistance was 5.0, 18.2 and 13.8 percent. It is of interest to note that the germination percentage of the seed lot with 13.8 percent moisture was not seriously reduced with a dosage as high as 30,000r units, but with both measures of seedling vigor there was a consistant decrease throughout the range of dosages. The same relationship was true for the high moisture seed except that the sensitivity was more pronounced at successively higher dosages. This result indicates that at the lower doses there is damage reflected in vigor of the seedlings, but not sufficient to destroy germination. This effect might be expected since in order to kill a seedling it would be necessary to destroy either the growing point of the plumule or radical, or both, whereas damage to the growing points of the rudimentary leaves in the seed would not kill the seedling, but could retard growth and thus decrease seedling vigor. If it is assumed that the x-rays are evenly distributed over the embryo area, this suggests that the target expressing sensitivity as seedling vigor is larger than the target for seedling death.

Within rough limits the reaction of oat seeds with varying moisture contents is similar in sensitivity to radiation effects in barley. In both species the order from least to greatest sensitivity was medium, high, and low moisture seed. Whatever the factor that causes this phenomenon it appears to be similar in both diploid barley and hexaploid oats and hence level of polyploidy has little effect upon the relationship between moisture content and x-ray sensitivity of seeds.

An observation which was not readily explainable was the apparent independence in the 5 percent moisture seed of x-ray damage and the dosage applied. At all doses the damage was extremely severe. The data from Caldecott (1) and from this experiment suggest that

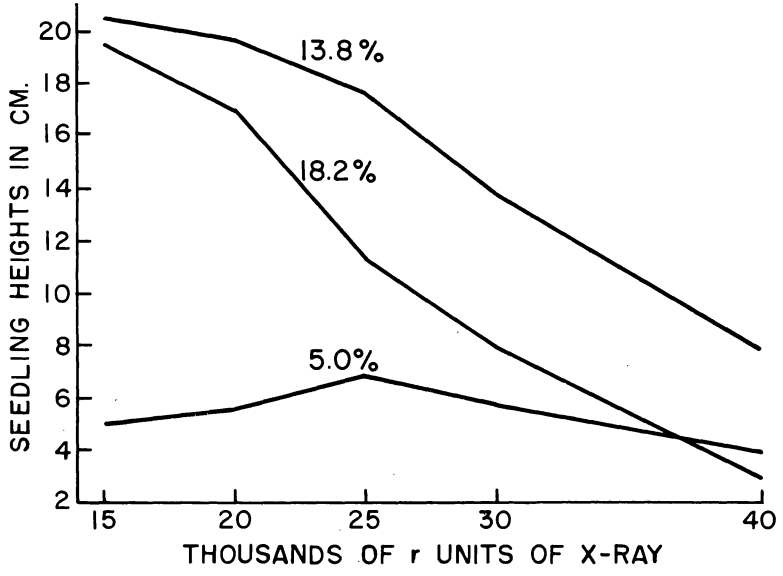

Figure 2. Average heights of oat seedlings produced from seeds with varying moisture levels and treated with different dosages of x-ray.

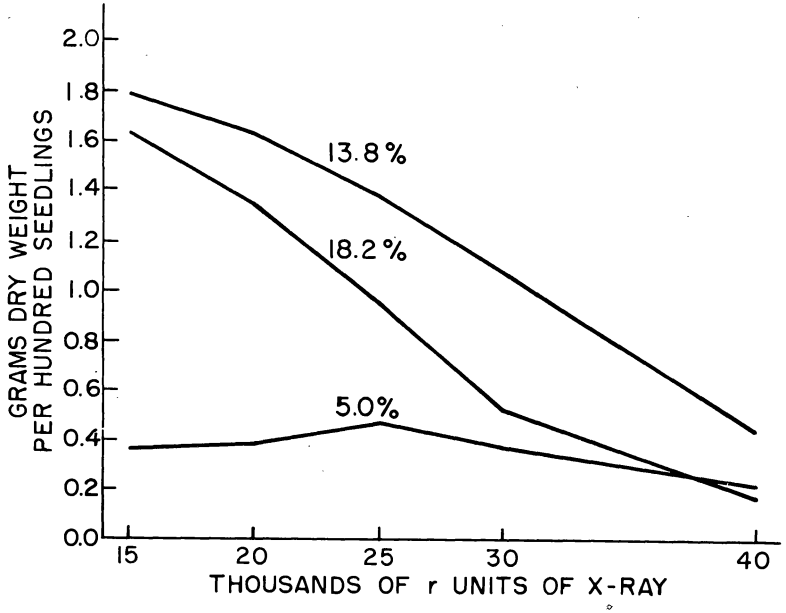

Figure 3. Weights per hundred oat seedlings produced from seeds with varying moisture levels and treated with different dosages of x-ray.

Gustafsson's (3) report of a positive relationship between moisture content and x-ray sensitivity of seeds may have resulted from increased metabolic activity in the high moisture seed. Since the moisture content of seeds in the early experiments was changed by soaking the seed at room temperature, great metabolic activity may have been initiated and thus increased sensitivity could be due, not to water content, but to the increased metabolic rates which made the chromosomes more sensitive to x-ray damage. When seeds are tempered to a certain moisture content by being placed in an atmosphere with a given relative humidity the metabolic rate would not be increased materially; thus the effect of moisture content would be measured independently of metabolic activity. Caldecott (1) soaked barley seeds at 3° C. to keep metabolic activity at a minimum while increasing the seed moisture content. Seeds tempered in this way reacted in the same way to x-ray treatment as those tempered in a desicator atmosphere.

Summary

Various x-ray dosages ranging from 15,000 to 40,000r units were used in treating hexoploid oat seeds with moisture contents of 5.0, 13.8, and 18.2 percent. From this experiment the following conclusions were drawn:

1. Seeds with 5.0 or 18.2 percent moisture were more sensitive to x-ray treatment than was seed with 13.8 percent moisture as measured in terms of either germination percentage or seedling vigor.
2. The x-ray sensitivity of seeds with 5 percent moisture was more independent of x-ray dosage than those with 13.8 and 18.2 percent moisture.
3. It is suggested that where soaking has been used to temper seeds a given moisture content the observations on x-ray sensitivity may have been confounded with metabolic activity.

Literature Cited

1. Caldecott, R. S. Inverse relationship between the water content of seeds and their sensitivity to x-rays. Sci. 120:809-810. 1954.
2. Caldecott, R. S. Affects of ionizing radiations on seeds of barley. Radiation Research 2:339-350. 1955.
3. Gustafsson, A. Mutations in agricultural plants. Hereditas 33:1-100: 1947.

Department of Agronomy
Iowa State College
Ames, Iowa