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Effect of Seed Size and Hulls Upon X-Ray Sensitivity of Oat Seeds[1]

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Abstract. Apparently the hull covering on oat seeds afforded some protection to the seed from X-rays, although the degree of protection varied among varieties. At X-ray dosages of 30,000r to 40,000r the large seeds were damaged more than the small ones when measured by germination percentage or reduction in seedling vigor. The damage from X-rays was not completely related to the germ sizes of the 2 seed classes.

The sensitivity of oat seeds to high doses of X-ray varies with many factors such as variety, seed size, and moisture content. The sensitivity to X-ray treatment usually is measured in two ways, namely, reduction in seed viability and reduction in vigor of X_1 seedlings.

Caldecott (1955) found a decrease in the sensitivity of barley seeds when the moisture content was raised from 4 to 8 percent, but little change over the range 8 to 16 percent. Abrams (1956) treated 4 oat varieties with 20,000r of X-ray and found that the germination percentage among varieties differed significantly (Table 1). Park

Table 1

Germination Percentages of 4 Oat Varieties Treated With X-rays

X-ray dosage (r)	Mo. 0-205	Bonham	Simcoe	Park
20,000[a]	29	29	39	56
0	87	87	89	92

[a]Seed contained 20.8% moisture.

was the most resistant to X-ray damage and Bonham and Mo. 0-205 the most sensitive. The seeds of all varieties used in this experiment were grown under the same environmental conditions, so any differences in germination after X-ray treatments most likely were due to inherent variation among varieties.

Froier and Gustafsson (1941) treated Kolben and Velvet wheat varieties with 10,000r and 20,000r and found large seeds were affected less by X-rays than were small ones. The same authors discovered that a hull covering on oats and barley caused the seed to be less susceptible to radiation effects. Abrams (1956) found

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large seeds of 3 of the 4 varieties tested more sensitive than small ones.

The purposes of the present study were to investigate whether variability in seed size or hull covering might account for the different sensitivities of oat varieties to X-rays and to ascertain whether germ size was responsible for the reaction of large and small seeds to X-rays.

Materials and Methods

For all experiments the oat seeds were tempered to 13.8 percent moisture before the X-ray treatment by keeping them in a desiccator over a saturated saline solution for 2 weeks. The radiation was done with a G.E. Maxitron X-ray machine operated at 250 kvp and 30 ma with the radiation filtered through a .25 mm. Cu + Al filter.

Within 24 hours after radiation the seeds for each experiment were planted 1 inch deep in the greenhouse in flats containing a sterilized soil mixture of loam, peat, and sand in the ratio of 2 : 1 : 1. A plot consisted of 100 seeds sown in a row across a flat and from 6 to 10 rows were sown per flat. In each experiment the design was a randomized block with 3 replications. The X-ray damage to the oat seeds was determined by the germination percentages and seedling heights in centimeters 21 days after planting.

The effect of hulls on X-ray damage to oat seeds was investigated by using hulled and dehulled seeds of uniform size from the 3 varieties Mo. 0-205, Simcoe, and Bonham. For the radiation treatment the seeds were placed in a circular plastic container 3 inches in diameter and divided into 4 quarter-circle compartments; thus 4 different seed lots were irradiated simultaneously. The dosage in this experiment was 30,000r.

For the investigations involving seed size and X-ray sensitivity 3 experiments were conducted with dehulled Bonham seeds. These experiments were not run simultanously, but the only mechanical variation in their conduct was in total X-ray dosage and the way in which the seeds were placed during the treatment. In the first experiment of this series the seeds were placed on a piece of cardboard with the germ face upward, alternating large and small in a single layer around the circumference of a circle to insure more nearly equal X-ray dosage to each seed than was possible in the plastic container. The centers of the circle and the X-ray target area coincided so that the X-rays were uniformly distributed over the seeds. The X-ray dosage for this experiment was 25,000r units.

In the second experiment the seeds were treated in the plastic container with a dosage of 35,000r of X-ray. The container was shaken every 10 minutes during the radiation treatment to change the position of the seeds and thus give a more uniform X-ray dosage to the seeds.

In the last experiment the seeds were stuck on a flat cardboard surface measuring 12 cm. x 16 cm. in alternating rows of large and small seeds. The distance from the anode to the target was 32.5 cm., so that the center portion of the cardboard (8 cm. x 8 cm.) received a higher dosage than the surrounding area. To compensate for this, the cardboard was cut so that the center portion could be removed when the seeds on it had received the proper dosage. The surrounding area remained under the machine until it had received an equivalent dose. The X-ray dosages were 30,000r and 40,000r in this experiment.

Table 2

Germination Percentages of Hulled and Dehulled Oat Seeds Containing 13.8 Percent Moisture and Radiated With 30,000r of X-ray

Variety and kind of seeds	Radiated seeds	Non-radiated seeds	Check[a] seeds	Radiated / non-radiated
Mo. 0-205				
Hulled	20	94	99	21
Dehulled	1	61	—	2
Bonham				
Hulled	55	75	98	73
Dehulled	4	47	—	9
Simcoe				
Hulled	49	75	99	65
Dehulled	18	53	—	34

[a]Check contained 8.5% moisture.

Experimental Results

Radiation with 30,000r of X-ray (Table 2) reduced the germination of all 3 oat varieties. The reduction for the hulled seed was greatest for Mo. 0-205. The germination percentages of the dehulled seeds were lower than those of comparable hulled seeds, but the radiation effect was hard to interpret because of detrimental effects from tempering the dehulled seeds. The non-radiated dehulled seeds germinated only about two-thirds as well as the corresponding hulled seeds. Nevertheless, when the germination of irradiated seeds is expressed as a percent of the non-radiated ones (last col., Table 2), it appears that the hull afforded some protection against X-ray damage.

The germination percentages and the seedling heights (expressed in percent of the check) for large and small dehulled seeds of Bonham variety treated with different X-ray dosages are shown in tables 3 and 4, respectively. In none of the experiments did tempering the seeds to 13.8 percent moisture appear to lower the germination percentage per se. At all dosages above 30,000r the germination percentages of the large seeds were lower than those of the small ones. There was an increasing difference between the two seed sizes as the X-ray dosage increased, until at 40,000r the large seed germination was reduced by one-third whereas the small seed germination was reduced only slightly. These results were contrary to those reported by Froier and Gustafsson (1941), who found small seeds to be affected more than large ones. Perhaps

Table 3

Germination Percentages of Large and Small Dehulled Seeds of Bonham Oat Variety Containing 13.8 Percent Moisture and Treated With Varying X-ray Dosages

Seed size	X-ray dosage (r)	Treatment Radiated	Non-radiated	Check[b]
Large	25,000	92	99	97
Small	25,000	97	99	99
Large	30,000	95	96	—
Small	30,000	96	100	—
Large	35,000[a]	87	98	99
Small	35,000	96	99	98
Large	40,000	66	96	—
Small	40,000	94	100	—

[a]Radiated in plastic container.
[b]Seed contained 8.5% moisture.

Table 4

Seedling Heights as Percent of Non-radiated Checks from Large and Small Dehulled Seeds of Bonham Oat Variety Containing 13.8 Percent Moisture and Treated With Varying X-ray Dosages

Seed size	X-ray dosage (r)	Treatment Radiated	Non-radiated	Check[b]
Large	25,000	63	106	100
Small	25,000	65	103	100
Large	30,000	64	100	—
Small	30,000	75	100	—
Large	35,000[a]	46	92	100
Small	35,000	66	98	100
Large	40,000	45	100	—
Small	40,000	64	100	—

[a]Radiated in plastic container.
[b]Check contained 8.5% moisture.

their data would have been different had they used another X-ray dosage.

The seedlings from the non-radiated large seeds were always significantly taller than those from the small ones; and, consequently, any difference in heights between the seedlings from radiated large and small seeds would be confounded with the initial difference between the seed-size classes. Therefore the seedling heights were converted to percentages of their respective checks (Table 4).

At 25,000r the seedling heights were reduced the same percentage in both seed-size classes, but at 35,000r and 40,000r the seedling heights were reduced approximately 55 percent for the large seeds and only about 35 percent for the small ones.

With both methods of measuring X-ray damage to oat seeds, namely, germination percentages and seedling heights, the large seeds were more affected than the small ones. The differential damage between the seed-size classes became greater as the X-ray dosage was increased from 25,000r to 40,000r.

Discussion

Since the embryo of the oat seed is the portion which expresses the extent of damage from X-ray treatment, the small seeds might be affected less than the large ones because they present a smaller target. The average weights of the germs from the large and small seeds of Bonham variety were 0.16 gm. and 0.12 gm., respectively (Table 5), and the germ surface areas were 281 and 225 square units, respectively. The ratios (small to large) for weight and surface were 0.75 and 0.80, respectively. The ratios of damage for large to small seeds measured by reduction in relative plant height (Table 6) varied from 0.97 at the 25,000r level to 0.70 at 35,000r and 40,000r. At the low dosage the ratio of damage was higher than either the germ-weight or surface-area ratios, and at the higher dosages it was smaller, indicating that the germ-size theory could not account for all of the differential damage of large and small oat seeds caused by high dosages of X-rays. Two factors complicate an interpretation of these data on the basis of target size. First, the real targets may be the growing points, which were not measured, and secondly, differential ratios of damage with varying X-ray dosages could result from a double hit pattern.

The germination percentages were actually a measure of the seedlings which had broken the ground surface within 21 days. In some instances these percentages were reduced to less than 20, whereas, when the seeds from the same lots were placed on moist blotters they invariably germinated above 95 percent. Probably the same percentage of seeds sprouted in the greenhouse soil as on the blotters, but in the greenhouse the seedlings had to grow through an inch

Table 5

Weights of Germs and Endosperm of Large and Small Seeds of Bonham Oats

Item	Large seeds	Small seeds
Weight per 100 dehulled seeds (gms.)	3.94	2.53
Dry weight of germ (gm.)	0.16	0.12
Dry weight of endosperm (gms.)	2.52	1.67
Per cent germ	6.35	7.19
Surface area of germ[a]	281	225

[a]Square units.

Table 6

Ratios of Relative Seedling Height Reduction of Large to Small Seeds of Bonham Oat Variety Subjected to Varying Doses of X-rays

X-ray dose (r)	Ratio of damage (Large seed : small seed)
25,000	0.97
30,000	0.85
35,000	0.70
40,000	0.70

of soil before they were classed as germinated. The seedlings which lacked the vigor to break the soil surface were classed as dead, whereas on blotters any seed which sprouted was classed as germinated. Perhaps both the reduced germination (seedling emergence) and seedling height were manifested by reduced vigor and not by seed lethality.

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