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E. Ruan
Iowa State College

K. J. Frey
Iowa State College

Effect of Heat Treatment on Oat Seeds[1]

By E. RUAN and K. J. FREY[2]

One method of handling oat grain with a moisture content too high for safe storage is artificial drying. This practice involves forcing heated air through the grain until the moisture content is reduced to the 13.5 percent considered safe. Problems inherent with this practice are the maximum grain moisture content at which artificial heat can be applied safely, and the maximum temperatures that can be used for drying.

Reiss (6) found that a drying temperature of 100° F. was less harmful to corn seed viability than either 110° F. or 120° F., whereas McRostie (5) concluded that corn with 30 percent or less moisture could be dried at 125° F. without harmful effects. The germination of rice seeds dried at 122° F. and 130° F. for one, two, and three hours was unaffected according to Jones (4), but 152° F. applied for three hours was lethal.

Jones (4) found that air dried rice seeds were killed by temperatures between 190° F. and 205° F. applied for one hour. Atanasoff (1) reported that the germination of air dried grain of four oat varieties was reduced 12 and 20 percent when treated at 212° F. for 15 and 30 hours, respectively. Burgess (2) found that 194° F. had no effect on the viability of air dried oat seeds. Grabe (3) showed that drying at 170° F. for two hours did not affect the germination of smooth bromegrass seeds when the moisture content was 20 percent and seeds with 14.3 percent moisture were unaffected by drying at 210° F. for four hours.

Another moisture problem in oats stored in bins are the so-called "high moisture pockets." These result from grain absorbing considerable moisture from green plant material buried in the grain. Weeds commonly cause this condition. The moisture tends to be trapped and considerable heat is generated. Since neither is dissipated rapidly by air circulation, this is similar to heating grain with a constant moisture content; a considerably different phenomenon than applying heat to dry grain. Grabe (3), working with smooth bromegrass seeds with moisture contents ranging from 56.6 to 13.2

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percent, found that the thermal death point of samples with more than 20 percent was 122° F. Samples with over 13, but under 20 percent, were injured by 140° F. and those with 2.6 percent withstood temperatures of 212° F.

In general, the purpose of the study reported herein was to determine if oat seeds react to heat treatment in the same way as other cereal grains. Specifically, the objectives were: (a) to determine the effect of 105° and 125° F. drying temperatures upon seeds with different initial moisture contents, and (b) to determine the thermal death points of oats with different constant moisture contents. The criteria used to measure the heat treatment effects were germinating percentage and the vigor of the seedlings grown from treated seeds.

Table 1
Moisture Percentage of Oat Seeds Harvested at Different Intervals After Anthesis.

Days after anthesis	Moisture content	
	Mo. O-205	Sauk
16	—	52.6
19	—	48.8
20	52.2	—
22	—	44.0
23	46.4	—
24	—	38.4
26	43.1	—
27	—	28.8
29	39.9	20.3
30	—	16.2
31	28.3	—
32	—	15.8
33	—	13.2
34	22.4	—
36	15.4	—
37	13.8	—

Materials and Methods

The oat seeds used for the temperature treatment experiments were harvested from the varieties, Mo. O-205 and Sauk, grown at Ames, Iowa, in 1955. A solid drilled planting of each variety was divided into six areas to represent replications. At a given harvest date seed from several rows was harvested from each replication.

When the moisture content of the grain of Mo. O-205 was 52.2 percent (20 days after anthesis) a sample was harvested from each replication by stripping the spikelets from the upper halves of the oat heads. Only the upper half of each head was harvested to insure a uniform stage of development in the seeds. Similar harvests were made subsequently to obtain grain with the moisture contents shown in Table 1. Each sample was divided into three parts: one for moisture determination, one for air drying to be used as a check, and one for thermal death point tests. For the latter tests the oat

seeds were sealed in 4-ounce screw cap glass jars to maintain a constant moisture content throughout the heat treatment. The jars of seeds were treated at 122° F., 149° F., and 176° F. for four, eight, 12 and 20 hour periods. After the moist heat treatments the grain was dried at room temperature. This procedure was used to simulate conditions in bins of stored grain with high moisture pockets where moisture and the generated heat could not escape readily.

Starting when the moisture content of Mo. O-205 grain was 43.1 percent, samples of three pounds each were placed in mesh bags and dried with air heated to 105° F. and 125° F. The seed was removed from the driers when the moisture content was approximately nine percent.

The same schedule was used in treating seeds of Sauk except that the moist and drying heat treatments were begun when the grain contained 52.6 and 44.0 percent moisture, respectively.

About two months after the last harvest, seed samples from each treatment were planted in flats in the greenhouse to determine germination percentages of the seed and the vigor of the seedlings produced. A plot consisted of 100 seeds from a given treatment sown in a row in a wooden flat. The plots were planted ten per flat, one-half inch deep, in a sterilized soil mixture composed of soil, sand, and peat in a ratio of 2:1:1. The greenhouse experimental design was a randomized block with six replications. Each greenhouse replication was planted with seed harvested from its counterpart in the field. Each variety was grown in a separate experiment.

Germination percentages and seedling vigor determinations were made 21 days after planting. All seedlings which emerged from the soil were included in the germination percentage regardless of their vigor and seedling vigor was expressed as grams of dry weight per 100 seedlings cut at the soil surface.

EXPERIMENTAL RESULTS AND DISCUSSION

Drying Treatment

The effect of drying temperature on the germinability of oat seeds of Sauk and Mo. O-205 varieties harvested with different moisture contents are shown graphically in Figure 1. Since the varieties reacted similarly the data were averaged to construct the graph. The germination of the seed dried at room temperature averaged 98 percent at all moisture levels.

There was a tendency for the seed dried at 105° and 125° F. to germinate about 0.5 percent higher than the check when the initial moisture level was below 20 percent. However, this difference was not significant. The 105° F. drying treatment caused little reduction in germination except in the grain which initially contained 44 per-

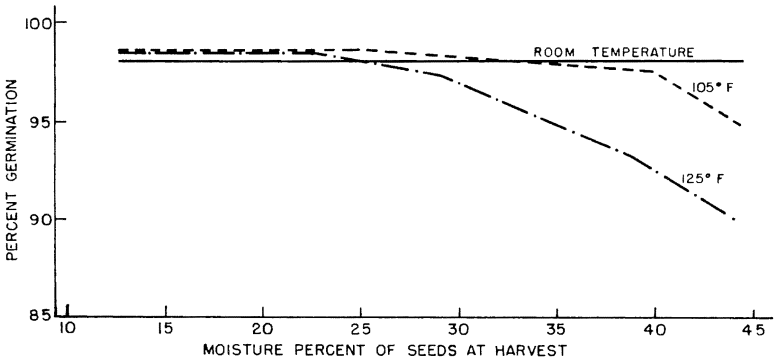

Figure 1. Average germination percentages of oat seeds of two varieties harvested at different moisture contents and dried at room temperature, 105° F., and 125° F.

cent moisture. Drying at 125° F. caused a marked decrease in germination when the moisture content of the grain was above 22 percent.

The vigor of the plants produced by the seeds subjected to different drying temperatures, expressed in weights per hundred seedlings, are presented in Figures 2 and 3 for Mo. O-205 and Sauk, respectively. The trend for both varieties was similar, but the Sauk seedlings were heavier than those of Mo. O-205. The seedling weights of both decreased when the seed contained more than 30 percent moisture at harvest. The drying temperature apparently had little if any affect on the weight per hundred seedlings. Within a variety the curves, for room temperature, 105° and 125°, closely approximate one another. Any tendency toward lower seedling vigor from high moisture seed is present in the check to the same extent as in

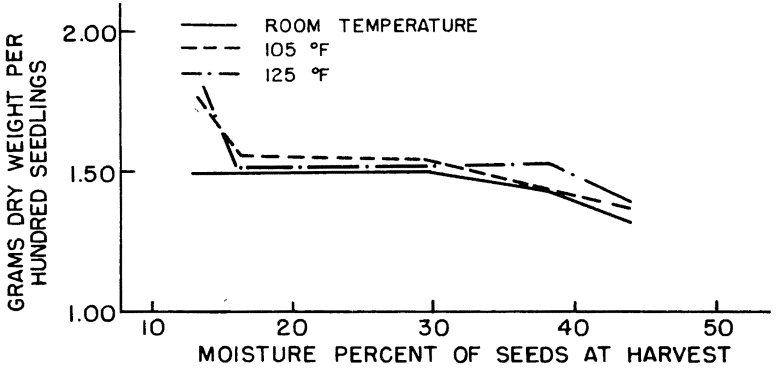

Figure 2. Dry weights in grams per hundred seedlings produced from oat seeds of Mo. O-205 variety harvested at different moisture contents and dried at room temperature, 105° F. and 125° F.

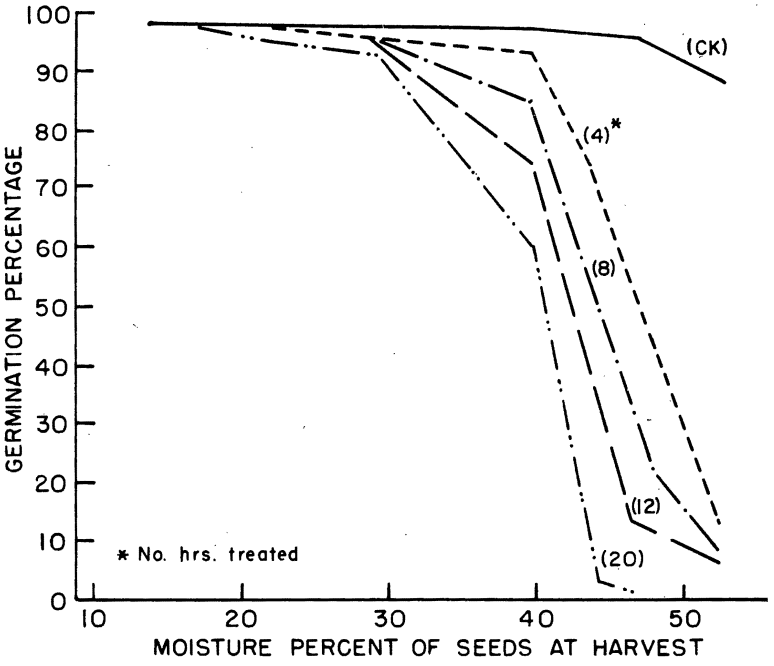

Figure 3. Dry weights in grams per hundred seedlings produced from oat s eeds of Sauk variety harvested at different moisture contents and dried at room temperature, 105° F. and 125° F.

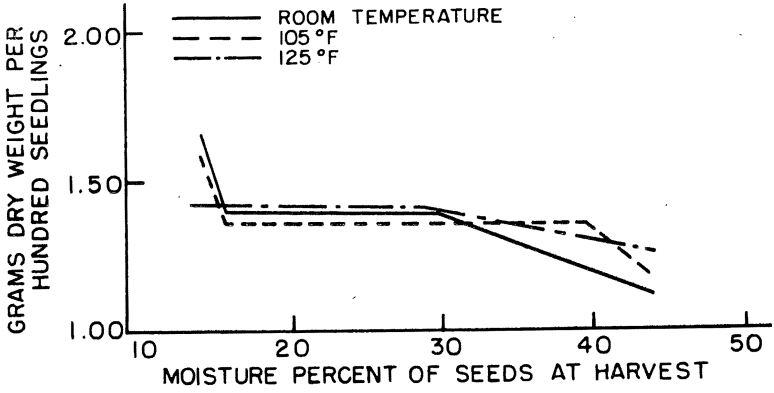

Figure 4. Germination percentages of oat seeds of Mo. O-205 variety with diff erent moisture contents, after treatment with 122° F. in sealed containers for 4, 8, 12 and 20 hours.

the artificially dried samples. An interesting, though unexplainable, feature in Figures 2 and 3 is the sudden upward trend at the lowest moisture level in four of the six curves. One of these is a check while three are from artificial drying treatments.

Most of the grain that would need to be artificially dried after harvest would contain less than 22 percent moisture. Apparently such seed could be artificially dried with temperatures at least as high as 125° F. with no detrimental effects on the seed germination or on the seedlings produced. In those cases where oat seeds would be harvested at a moisture level above 22 percent for special studies 105° F. could be used safely for drying. Even at the 44 percent moisture level the germination reduction from drying at 105° F. was only three percent. These results corroborate the studies with other cereal crops (4, 5, 6).

Table 2

Germination Percentages of Oat Seeds of Two Varieties with Different Moisture Contents after Heat Treatment of 149° F. in Sealed Containers for 4, 8, 12, and 20 Hours.

Moisture at harvest (%)	Length of Treatment				
	Ck.	4 Hrs.	8 Hrs.	12 Hrs.	20 Hrs.
			Mo. O-205		
22.4	98	0	0	0	0
15.4	98	40	4	5	4
13.8	98	97	91	80	86
			Sauk		
20.3	99	0	0	0	0
16.2	99	18	2	2	1
15.8	99	35	7	2	0
13.2	98	77	14	10	5

Moist Heat Treatments

The germination percentages of oat seeds of Mo. O-205 and Sauk varieties harvested at different moisture contents and treated in sealed containers at 122° F. for various time intervals are shown in Figures 4 and 5, respectively. Similar data for the 149° F. treatments are presented in Table 2. The 176° F. temperature killed all of the seeds irrespective of moisture content or interval of treatment.

The germination of the check was above 90 percent for the grain harvested with a moisture content of 45 percent or less. Above 45 percent there was a slight decrease in the germination of the check. The viability of Mo. O-205 seed which contained less than 30 percent moisture was affected very little by 122° F. regardless of the length of the treatment interval. However, at 40 percent moisture and above the reduction in germination was related to the treatment interval. At the 52 percent moisture nearly all of the seeds were killed even at the four-hour interval. Sauk reacted similarly except

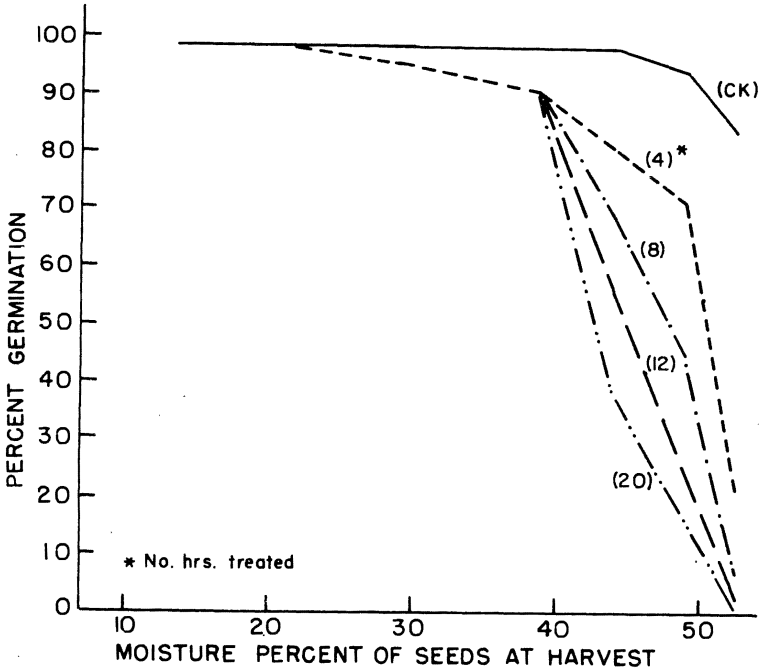

Figure 5. Germination percentages of oats seeds of Sauk variety with different moisture contents, after treatment with 122° F. in sealed containers for 4, 8, 12 and 20 hours.

that the differential reaction to treatment intervals was not apparent until the seed contained 44 percent moisture. All of the treatment intervals caused a slight decrease in seed viability between the 20 and 40 percent moisture levels.

All of the seeds which contained 20 percent or more moisture were killed by 149° F. regardless of the length of treatment interval. At 15.5 to 16.0 percent moisture the germination was reduced more than half with the four-hour treatment and longer intervals caused nearly a complete kill. The varieties gave a differential reaction to the 149° F. when the seed moisture content was below 14 percent. The germination of Sauk ranged from five to 14 percent when treated for periods of 20, 12, and 8 hours, whereas comparable percentages for Mo. O-205 were from 80 to 91. This reaction was unexpected since the moisture content of Mo. O-205 was 0.6 percent higher than that of Sauk.

Weights per hundred seedlings from the 122° F. moist heat treatments are presented in Figures 6 and 7 for Mo. O-205 and Sauk, respectively. For Mo. O-205 the weights per hundred seedlings for

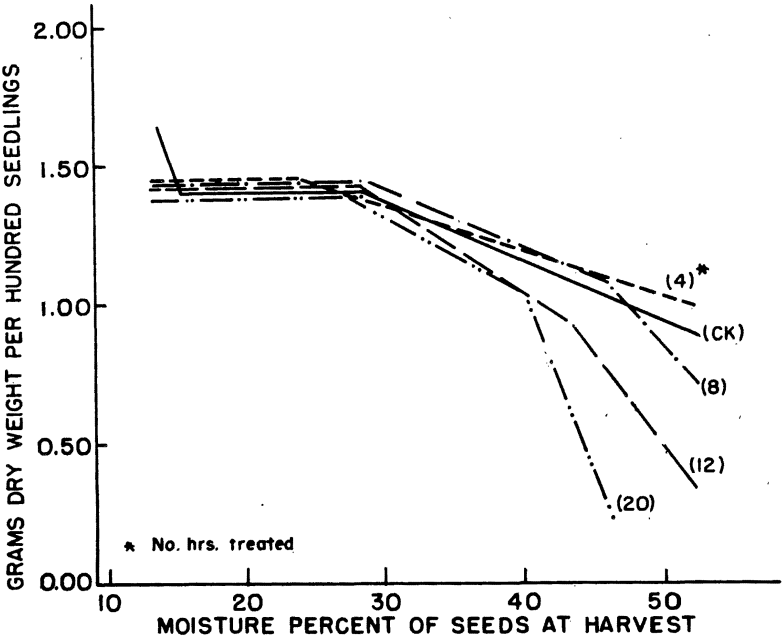

Figure 6. Dry weights (grams) per hundred seedlings grown from oat seeds of Mo. O-205 variety with different moisture contents, after treatment at 122° F. in sealed containers for 4, 8, 12 and 20 hours.

all treatment intervals were similar to the check when the grain moisture content was 40 percent or less. Above 40 percent moisture the 4- and 8-hour treatments gave the same trend as the check. However, the 12- and 20-hour treatments caused a more rapid rate of decrease than the check. The data were not as uniform for Sauk variety, but all of the curves, irrespective of the treatment interval, tended to follow the same trend as the check. Seedling weights for the 149° F. treatment were in most cases, based on so few seedlings that they were considered unreliable.

It appears that oat seeds held at a constant moisture level of 30 percent or below will withstand a temperature as high as 122° F. for 20 hours without causing any marked detrimental effects on seed viability or the vigor of seedlings produced by the seed. The effect beyond 20 hours was not within the scope of this study, but very likely, pockets of high moisture grain in a bin do persist for longer periods than 20 hours. It is also possible that temperatures higher than 122° F. may exist in high moisture pockets.

The varietal reaction seemed to reverse at the two temperatures, 122° F. and 149° F. The differential reaction of Sauk to treatment

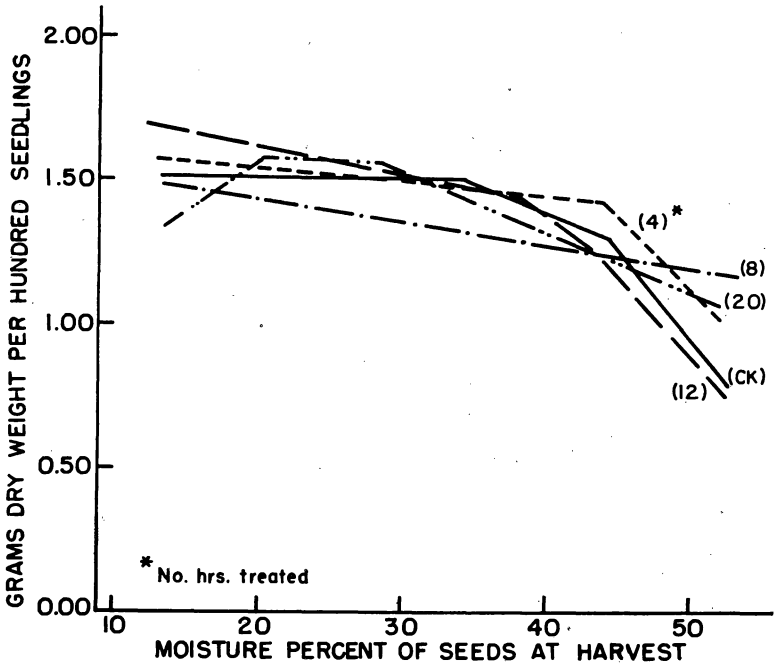

Figure 7. Dry weights (grams) per hundred seedlings grown from oat seeds of Sauk variety with different moisture contents, after treatment at 122° F. in sealed containers for 4, 8, 12 and 20 hours.

interval at 122° F. occurred at a higher moisture level than it did in Mo. O-205. Contrariwise, at 149° F. Mo. O-205 was resistant at a higher moisture content than was Sauk. The 176° F. treatment killed all seeds of both varieties. These data seem to indicate that oat seeds are somewhat more susceptible to heat than reported by Burgess (2).

Summary

From experiments to determine the effect of heat treatments, either dry or moist, on oat seeds with different moisture contents the following conclusions were drawn:

1. Drying temperatures up to 105° F. caused no reduction in seed viability when the initial moisture content was 40 percent or less. Drying at 125° F. was safe for grain containing no more than 22 percent moisture.
2. Seed dried at either 105° F. or 125° F. produced seedlings with vigor equal to the air dried check even for seed with a moisture content as high as 45 percent at harvest.

3. Seeds with up to 30 percent moisture could be treated in sealed containers with 122° F. for as long as 20 hours without a loss in seed viability or seedling vigor. However, 149° F. killed seeds which contained more than 20 percent moisture and 176° F. was lethal to all seeds treated.

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Department of Agronomy
Iowa State College
Ames, Iowa