Bulletin No. 352 - Heat-Treating Hard Alfalfa Seed

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HEAT-TREATING

hard alfalfa seed

by

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Bulletin 352
July 1957
SUMMARY

Hard seed of alfalfa can be made permeable by applications of properly regulated dry heat. Nineteen lots of Ladak alfalfa from 2 years' production were heat-treated by machine. The average percentage of hard seed was reduced from 41.3 percent in the checks to 16.8 percent in the treated seed. Germination was increased by the corresponding amount.

Different lots of alfalfa seed vary one from another in response to the same heat treatment.

A time/temperature relationship exists in attaining the maximum reduction in percentage of hard seed in alfalfa.

Heat treatments must be applied with the proper time/temperature relationship, or a danger exists whereby the viability of a lot of seed can be destroyed by overheating.

Heat treatments that cause hard seed of alfalfa to become permeable do not produce visible abnormalities in the resulting plants.

Alfalfa seed which had been treated with dry heat retained initial benefits for 17 months without loss of viability.

Tests with a pilot-model heat-treating machine indicate that alfalfa seed can be heat-treated commercially to lower the percentage of hard seed.
Heat-Treating Hard Alfalfa Seed

By Clarence M. Rincker

Introduction

Considerable attention is turned every so often to the high percentage of "hard seed" found in northern-grown alfalfa seed. Seedsmen and farmers in the alfalfa-seed-consuming areas from time to time have been reluctant to buy such seed. Consequently, northern seedsmen have sought various ways to reduce the percentage of hard seed to tolerances considered acceptable by the seed purchasers, and thus make the seed more salable.

The condition that is referred to as "hard seed" in legumes is in reality an impermeable seed with a coat that is impervious to water and that will not permit the seed to germinate when placed under normal conditions. This condition is not permanent, as the seedcoats will become permeable in time or by the action of certain treatments. Hand-picked alfalfa seed in Wyoming has frequently tested as high as 90 percent hard seed in a germination test soon after harvest. Machine-harvesting with field combines usually renders many of the seeds permeable to the extent that the percentage of hard seed is lowered to 60 or 65 percent or lower. Five months after harvesting, the same seed, without further treatment, will usually test from 30 to 50 percent hard seed.

Several investigators (3, 4, 6, 10, 11, 12) have demonstrated that, for all practical purposes, nearly 100 percent of the hard seed found in alfalfa is viable seed and will grow either in the laboratory or under field conditions. Tests by Dexter (1) have shown that alfalfa seed high in hard seed establishes better stands under adverse field seeding conditions than seed low in hard seed planted under the same conditions. Agronomists generally agree that a reasonable percentage of hard seed is to the farmer's advantage rather than disadvantage. In spite of this knowledge, growers still discriminate against alfalfa seed containing a high percentage of hard seed. This may stem in part from confusion with certain other legumes in which hard seed is definitely undesirable, or perhaps from some recent advertising in which low hard-seed content is mentioned.

The practice of scarifying alfalfa seed, common 30 to 40 years ago, almost disappeared after articles showing that scarified seed lost viability rapidly. Scarification is currently being resumed by some seed processors in attempts to overcome the present buyer resistance to hard seed. In some cases, seed treatments are being applied after scarification in an attempt to retard the loss in viability. Other seed processors are using various company methods of lowering the hard-seed percentage.

1The work reported here was conducted in part as a project of the Department of Agronomy. The author is grateful to Charles E. Allen, former State Seed Analyst, and to Paul J. Hall, present State Seed Analyst, for their cooperation and use of the facilities of the Wyoming State Seed Laboratory.

2Research Assistant in Agronomy and Seed Certification Manager. Resigned May 1, 1957.
Investigations begun in Wyoming in 1949 have involved the effect of dry-heat treatments on impermeable seeds of alfalfa, sweet clover, and red clover (7). Laboratory tests reconfirmed earlier studies made by other workers (2, 5, 8, 9) that dry heat would increase the germination of hard seed in alfalfa. The same tests showed that red clover responded to a lesser extent and that sweet clover showed very little response to heat treatments. Early investigators, however, found that heat treatments, to be highly effective on alfalfa, required 2 or more hours of treatment. Commercially this was too time-consuming (5, 9).

In one of the Wyoming tests, maximum reduction of hard seed in alfalfa was obtained in 1 hour at 190°F. The test was undertaken to observe the effect of a constant-time and variable-temperature relationship upon hard seed of alfalfa. One hour was selected for the constant length of time; treatments began at 100°F and increased by 10-degree intervals through 220°F. An untreated check was compared with 13 treated samples. All germination tests were conducted in the Wyoming State Seed Laboratory under official germination methods.

Figure 1 shows the results. Germination gradually increased from 27 percent in the check sample to 86 percent in the 190°F treatment. Likewise, the hard-seed percentage gradually decreased from 65 percent in the check to 3 percent in the 190°F treatment. The percentage of total (total refers to the sum of germination and hard seed) was not materially affected until 200°F was reached. It may be seen that 190°F was the
critical temperature in this test. Above 190° F. the heat treatments killed part of the seed, until at 220° F. there was no germination whatsoever, and only 4 percent hard seed remained. The heat for this test was supplied by an electric dry-heat oven thermostatically controlled.

**INFRARED HEAT TREATMENTS**

In a later test the source of heat was changed to a single 250-watt infrared bulb on a 110-volt circuit. The bulb was suspended above the seed at a height which produced a temperature of 220° F. on the seed. Five samples of seed were treated, one each for ½ minute, 1 minute, 1½ minutes, 2 minutes, and 5 minutes. A check was again employed to compare with the treated seed. Best results (see Table 1) were obtained in 1½ minutes at 220° F., where the germination was increased 47 percent and the hard seed reduced 44 percent, while the total remained as good as the check.

A portion of the infrared heat-treated seed was set aside and stored for 233 days (or more than 7 months) in a warm room and then tested to determine if treated seed would remain viable. It was also a check to determine if treated seed retained the benefits of the treatment if stored for a period of time before planting. As shown in Table 1, the treated seed not only remained viable but also retained the beneficial effect of the heat treatment.

In a later test, samples from 6 different lots of seed treated with infrared heat were stored for a period of 17 months; the germination was rechecked and compared with the check samples. As in the previous test, the treated seed remained viable; however, the hard seed in the check samples had decreased naturally to the extent that the heat-treated seed showed little advantage over the non-treated seed.

**TABLE 1—Alfalfa-seed germination after treatment with infrared heat at 220° F.**

<table>
<thead>
<tr>
<th>Time in which infrared heat was applied at 220°F.</th>
<th>Percentage of germination</th>
<th>Percentage of hard seed</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soon after treatment</td>
<td>After 233 days’ storage</td>
<td>Soon after treatment</td>
</tr>
<tr>
<td>Check (No heat)</td>
<td>33</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>½ Minute</td>
<td>40</td>
<td>55</td>
<td>49</td>
</tr>
<tr>
<td>1 Minute</td>
<td>72</td>
<td>89</td>
<td>13</td>
</tr>
<tr>
<td>1½ Minutes</td>
<td>80</td>
<td>88</td>
<td>6</td>
</tr>
<tr>
<td>2 Minutes</td>
<td>79</td>
<td>88</td>
<td>4</td>
</tr>
<tr>
<td>5 Minutes</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
MACHINE-TREATING WITH INFRARED HEAT

With the information obtained from the preliminary studies, plans included a device for applying the infrared heat treatment to alfalfa seed mechanically. A heat-treating machine was designed and constructed (Fig. 2). This machine consists of a special heat-resistant, 12-inch, endless rubber belt driven by a 1/4 h. p. electric motor through a variable-speed control and speed-reduction jacks. The endless belt passes through a plywood cabinet in which a battery of 8 infrared lamps, 250-watts each, were installed on a board that is adjustable for height. On one end a 60-pound capacity hopper feeds the seed onto the belt in an even, thin layer (Figs. 3 and 4). At the discharge end of the belt is a sack holder to hold a bushel bag into which the treated seed drops (Fig. 5). One side of the plywood cabinet is removable to facilitate changing of bulbs and measuring of height above the seed. The infrared bulbs are staggered so as to cover the entire width of the belt. The base is constructed of 2 x 4's and measures 9 ft. long by 2 1/2 ft. wide and 2 ft. high. The cabinet is 7 ft. long, 12 in. wide, and 26 in. high and constructed of 1/2-in. plywood.

It was found that, within the enclosed cabinet, the lights could be

FIG. 2—The pilot-model infrared heat-treating machine for treating alfalfa seed to reduce the percentage of hard seed. This machine was designed and constructed at the University of Wyoming, equipped with 8 infrared lamps, 250-watts each; later the machine was modified by adding 6 such lamps. Untreated seed is placed in the hopper at the right end and flows through the feeding device beneath the hopper onto the endless rubber belt in a thin layer of seeds. The belt carries the seed onto the heating cabinet, underneath the infrared lamps, and discharges the treated seed into the bushel bag at the left end. When in operation a removable door (removed in the above picture) is replaced and completely encloses the lamps. The belt is driven by a 1/4 h. p. electric motor after the power passes through a variable-speed control and speed-reduction jacks. These may be seen in the lower right end of the base.
adjusted from 2 in. above the seed to 10 in. above the seed without affecting the treatment. Therefore the lights were set at 3 in. above the seed, and the two adjusting rods that extend through the top of the cabinet with turn screws were no longer needed; neither was the extra space needed above the boards on which the lights are installed.

Length of the treatment is controlled by speed of the belt, which in turn is governed by a variable-speed control on the power from the electric motor. The machine was designed with a range in belt speeds from 5 to 55 ft. per minute. There is 7 ft. of belt exposed to the heat lamps within the cabinet. Therefore when the belt speed is set at 50 ft. per minute, the seed is exposed to the infrared heat only about 8.6 seconds.

The spreading is done with a strip of medium-hard rubber that has enough flexibility not to break seeds yet to keep them evenly spread.
FIG. 5—The author, inventor of the heat-treating machine, observing the heat-treated seed as it is discharged into the bushel bag. After passing through the heating cabinet, where the air temperature registers 280° F., the seed is so hot that it can not comfortably be held in the hand. The laboratory thermometer is suspended so the bulb just clears the seed.

THE 1955 MACHINE HEAT-TREATING TESTS

In March, 1955, soon after the heat-treating machine was built, 10 different lots of certified Ladak alfalfa seed from the 1954 crop were heat-treated. The machine was set at a belt speed of 6 ft. per minute with the heat lamps 3 in. above the seed. A check sample was drawn from each lot before it was treated, to be compared with the treated seed. The 10 lots of seed were selected on the basis of State Seed Laboratory tests made in November and December, soon after harvest, and ranged in hard seed from 48 percent to a high of 73 percent at that time. The average percentage of hard seed in the check samples in March was 48.1 percent, and after heat-treating the 10 lots they averaged 20.8 percent hard seed.

Results are shown in Table 2. The percentage of total remained fairly constant, while the percentage of germination increased in direct proportion to the decrease in percentage of hard seed. Also, some individual lots responded more than other lots. Before treatment the seed of all 10 lots had been uniformly stored for a period of 4 months to equalize the temperature and moisture content of the seed.

Even though this test produced very satisfactory results, it was decided to repeat the tests with seed grown in a different year, and at the same time to endeavor to increase the capacity of the machine.

One way to increase that capacity was to add more heat lamps. Six more 250-watt infrared lamps were installed between the lamps already in the machine. This brought the total wattage for the 14 lamps to 3500 watts. At a power rate of 3¢ per kilowatt, the cost of operating the machine for an 8-hour day would be 84¢ for the heat. With the machine thus re-
modeled, the air temperature within the cabinet registered 280°F. when in operation. It was then possible to increase the belt speed to 50 ft. per minute and obtain satisfactory results with a capacity of 275 lbs. seed/hr.

THE 1956 MACHINE HEAT-TREATING TESTS

Nine different lots of 1955 crop certified Ladak alfalfa seed were treated with the belt speed set at 50 ft. per minute. The average percentage of hard seed was lowered from 33.7 percent in the checks to 16.3 percent in the treated lots. The germination increased in direct proportion to the drop in hard seed.

After this test the belt speed was reset at 40 ft. per minute, and seed from the same 9 lots mentioned above was treated at this setting. Results are presented in Table 2. In this case, the average percentage of hard seed dropped from 33.7 percent in the checks to 12.3 percent in the treated lots. The germination percentage increased in direct proportion to the reduction of hard seed. The capacity of the machine at this setting was 250 lbs. of seed per hour.

| TABLE 2—Germination of Ladak Alfalfa Seed under Heat Treatment, 1955 and 1956 |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| November and December tests                  | April tests Check samples                      | April tests Heat-treated samples              |
| Year                                          | (number)                                       | (number)                                      |
| Germs. (number)                               | Hard seed (number)                             | Total (number)                                |
| Germ. (number)                                | Hard seed (number)                             | Total (number)                                |
| Germ. (number)                                | Hard seed (number)                             | Total (number)                                |
| 1955                                          |                                                |                                               |
| (average of 10 lots)                          | 33.5                                           | 57.5                                           |
|                                               | 91                                             | 40.8                                           |
|                                               | 48.1                                           | 88.9                                           |
|                                               | 67.5                                           | 20.8                                           |
|                                               | 88.3                                           |                                                |
| 1956                                          |                                                |                                               |
| (average of 9 lots)                           | 45.4                                           | 47.4                                           |
|                                               | 92.8                                           | 61.4                                           |
|                                               | 33.7                                           | 95.2                                           |
|                                               | 83.6                                           | 12.3                                           |
|                                               | 95.9                                           |                                                |

TESTS MADE WITH TREATED SEED

In Figure 6 one can observe the marked increase in number of sprouts on a germination blotter planted with treated and untreated seed. No visible differences could be observed in the individual sprouts from heat-treated seed compared with sprouts from untreated seed. However, it was considered advisable to plant treated seed in soil, and to observe the growth, to note whether any abnormalities should develop from heat-treated seed.

Treated seed was planted in greenhouse flats, 100 seeds per row, with parallel rows of 100 untreated seeds planted in the same flats. Sixteen days later, the rows from the treated seed had an average of 85 seedlings compared with only 49 seedlings in the rows from untreated seed. By laboratory test the untreated seed contained 64 percent hard seed and the treated seed 18 percent hard seed. Five months later the plants were dug up and recounted. The rows from
treated seed averaged 89 plants and the rows from untreated seed averaged 56 plants. At the time when the plants were dug up, there was no visible difference between the rows from treated or untreated seed except the thicker stand in the rows from treated seed.

In another growth test, a few treated seeds were placed in 8-inch greenhouse pots, and check pots were started at the same time with untreated seed from the same lot.

In Figure 7 the plants from treated seed are compared with plants from untreated seed when the plants were 5 months old. No visible differences existed at the end of 5 months. These pots were retained until the alfalfa plants bloomed and set seed. From visual observations, there was never a time during the growth of these plants that the plants from treated seed appeared any different from the plants from untreated seed. The heat treatment of the seed apparently leaves no aftereffect in the plants.

FIELD TRIALS WITH HEAT-TREATED SEED

In the spring of 1956 a field trial was set up in which treated and untreated seed of 9 Ladak alfalfa lots were planted in a randomized block trial with 4 replications. The treated seed was obtained from the experiment conducted in April with the heat-treating machine (See Table 2). The trial was planted in 10-ft. rows, 100 seeds to a row, for each treatment on the Agronomy Farm at Laramie. The purpose was to determine if heat-treated seed would perform satisfactorily under field conditions. About 10 days after planting, the rows planted with treated seed appeared to have better stands than the rows planted with untreated seed. However, 19 days after planting, when a stand count was taken there was only 3½ percent difference in the stands. The rather rapid germination of the hard seed in the untreated rows accounted for this nonsignificant dif-
ference. Observations throughout the remainder of the summer showed no apparent differences in the stands or appearance of the plants resulting from treated seed as compared with plants from untreated seed.

FIG. 7—These two 8-inch greenhouse pots were planted with a few alfalfa seeds at the same time. The pot on the right was planted with untreated alfalfa seed and the one on the left was planted with infrared heat-treated seed. Purpose was to determine if any visual differences or abnormalities would develop in the plants started from heat-treated seed. No differences were ever noted from the seedling stage until the plants set seed.

DISCUSSION

The results obtained by this investigator support the findings of others that proper application of dry heat to hard seed of alfalfa will make them permeable. The tests established that a time/temperature relationship exists in obtaining maximum reduction of hard seed; that is, the higher the temperature used, the shorter the time needed, or—the lower the temperature, the longer time needed. In so far as can be found in the literature, effective heat treatments have previously required 2 hours or longer because of the relatively low temperatures used. With the higher temperatures, this author shortened the time factor to 8.6 seconds in a machine application of the heat treatment. The pilot model machine used in these tests is apparently the first one constructed for heat-treating alfalfa seed to reduce the percentage of hard seed.

Although the size of the pilot model restricts the capacity below commercial desirability, larger machines with increased capacities can be built to use the principles learned in the series of tests conducted with the pilot model. The capacity of commercial machines can easily be increased

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through use of wider belts and longer heat cabinets.

The cost of operating an infrared heat-treating machine is surprisingly low. The pilot model could be operated for an 8-hour day with electricity for heat costing only 84¢ while treating 2000 lbs. of seed. In areas of lower power rates the cost would be still lower. Once adjusted, the heat-treating machine requires very little attention.

Heat-treated alfalfa seed has 3 advantages over seed scarified to reduce the hard seed percentages: (1) The treatment does not scratch, chip, or break any seed, hence does not necessitate recleaning or later shrinkage of the cleaned seed. (2) Heat-treated seed retains the benefit of the treatment over a long period of time without loss of viability as experienced in scarified seed. (3) It is not necessary to apply seed treatments in order to retain viability, as is sometimes practiced on scarified seed.

Improper use of heat treatments can damage the viability of alfalfa seed just as readily as improper use of a seed scarifier. This may come about by exceeding the thermal death point of the alfalfa seed when using high temperature. For this reason, heat treatments should be applied only with the intent of lowering the percentage of hard seed and not to eliminate hard seed. The presence of 20 to 30 percent hard seed in alfalfa is agronomically desirable, and if heat treatments are applied with this in mind, they can then be applied quite safely.

LITERATURE CITED