Reducing Seed Dormancy in Indian Ricegrass [*Oryzopsis hymenoides*]

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Abstract

Indian ricegrass [*Oryzopsis hymenoides* (Roem. and Schult.) Ricker] is an excellent native species for revegetation of coal and oil shale sites. However, inadequate germination due to a high seed dormancy results in poor stand development and limits its use. This paper presents the results of a series of experiments attempting to reduce the dormancy by weakening the lemma and palea by scarification of the seed covering. Four treatments (three mechanical and one concentrated sulfuric acid) were examined, alone and in combination with gibberellic acid. Three ages of seed were tested in the greenhouse, the laboratory and the field. Concentrated sulfuric acid and a modified commercial scarifier most effectively increased germination in the greenhouse; gibberellic acid enhanced germination of the younger, fresher seeds in this environment. A rubbing machine improved emergence in the field more than the other treatments. It was, however, only a modest improvement. Concentrated sulfuric acid decreased field emergence for all 3 ages of seed. Germination studies in the laboratory indicated that none of the treatments increased mortality.

Indian ricegrass [*Oryzopsis hymenoides* Roem. and Schult.) Ricker] is a native perennial bunchgrass adapted to a wide range of dry, infertile habitats. It is common on the foothills, plateaus, and plains of the western United States and Canada; it thrives in well-aerated rocky or sandy soils. The mature plant is a palatable and nutritious forage crop (Rogler 1960). The seeds, high in protein and fat content, are a popular feed of livestock and rodents (Hafenrichter et al. 1968). The plant tolerates heavy grazing (Stoddart and Wilkinson 1938) and is capable of controlling wind erosion (Bohmont and Lang 1957). These qualities make Indian ricegrass an important prospect for revegetation of coal and oil shale sites. However, its use for this has been limited because an inherent seed dormancy results in an inadequate germination and poor stand establishment.

Huntamer (1934) and Toole (1940) found 2 dormancy mechanisms responsible for the low germination: an indurate lemma and palea and a dormant embryo. They established that seed treatments which weaken the hard seed covering (the lemma and palea) improve germination. These authors, as well as Stoddart and Wilkinson (1938), Plummer and Frischknecht (1952), and McDonald and Khan (1977), concluded that scarification with formulations of sulfuric acid was the most effective means of weakening the seed covering and increasing germination.

Toole (1940) also found that prechilling for 28 days increased germination. Plummer and Frischknecht (1952) showed that a stratification treatment helped overcome embryo dormancy. Clark and Bass (1970) established that alternating temperatures also promoted germination.

Huntamer (1934) and Toole (1940) realized that aging alone reduced dormancy. Rogler (1960) tested the effect of age and confirmed that germination increased with time, but only to a point (approximately 6 years), after which it decreased. McDonald and Khan (1977) suggested that it is the embryo dormancy that is temporary and its effect decreases significantly after a year in storage.

Mechanical scarification also increases germination of the seed. Huntamer (1934) and Stoddart and Wilkinson (1938) reduced dormancy by removing the lemma and palea with a knife. Huntamer (1934), Toole (1940) and Plummer and Frischknecht (1952) rubbed the seed with sandpaper and emery paper. Toole (1940) also rolled seeds in a metal box with gravel to break the seed coat. Although successful in improving germination, both methods damaged the embryos of some seeds.

McDonald and Khan (1977) included hormones in their tests of methods to reduce dormancy. They found abscisic acid inhibited germination while gibberellic acid and kinetin stimulated it.

Methods of improving Indian ricegrass germination have thus been studied since 1934 (Huntamer 1934). To date, sulfuric acid to weaken the seed covering or exposure to moist, cold temperatures have been the most successful methods for enhancing germination of Indian ricegrass seed. This paper presents the results of a study of 9 mechanical, acid, and hormonal treatments. The effect of time was studied with seed of 3 ages. Furthermore, the treatments were tested in the greenhouse, the field, and germination boxes in the laboratory, to evaluate their relationship with environment.

Materials and Methods

Seed of the Warner Farm strain was collected in 1975, 1976, and 1977 near Greeley, Colo., in an attempt to represent different ages of seed. After being cleaned and graded, seed from each year was divided into 10 equal lots. One lot was left untreated as a control, each of the 9 remaining lots was then treated by one of the following methods: (1) commercial scarifier, (2) tumbler, (3) rubbing machine, (4) sulfuric acid (5) gibberellic acid (GA_3), (6) commercial scarifier plus GA_3, (7) tumbler plus GA_3, (8) rubbing machine plus GA_3, and (9) sulfuric acid plus GA_3.

The first 3 treatments, mechanical scarification techniques, attempted to increase germination by scratching the seed covering, weakening it. They are modeled after methods commonly used in the seed industry, especially with legumes. The fourth treatment, concentrated sulfuric acid, was used to weaken the seed covering chemically and thus decrease dormancy. The final 5 treatments tested the ability of GA_3 to counteract abscisic acid, alone and in combination with the first 4 treatments.

The commercial scarifier treatment used a Forsberg Line scarifier which had rotating batts propelling the seed against 40 grade sandpaper. One and a half minute treatments with a variable rheostat to maintain the batts' speed at 426 ± 25 rpm minimized embryo damage and maximized scarification.

The tumbler scarifier was modeled after a lapidary tumbler, using a 3/8-inch drill for a motor and a metal canister lined with 80 grade sandpaper for a tumbling chamber. Again variable rheostat kept the speed at an optimum 70 ± 5 rpm. A 1-hour treatment was determined to give good scarification with minimal damage.

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The rubbing machine had a vibrating flat lower surface and a stationary weighted upper surface between which the seeds were rolled for 5 minutes. The lower surface was topped with rubber to hold the seeds and to avoid crushing them. The upper surface was a wooden block covered with a layer of rubber, a layer of 80 grade sandpaper and weighted with 900 g of lead.

The sulfuric acid treatment described by McDonald and Khan (1977) was used as a model for the fourth scarification technique. Soaking in 36N acid lasted 35 minutes for all 3 ages. The duration was not varied for each age since that might be difficult in practice. The seeds were then washed in distilled water and allowed to air dry for 24 hours.

The gibberellic acid treatment, alone and in combination with the other treatments, followed the penetration method (acetone) suggested by Khan et al. (1973). The concentration recommended by McDonald and Khan (1977), 100 μmGA_3 for 90 minutes was used. After treatment the seeds were air dried.

Each lot of treated seed was dusted with 40% Maneb (McDonald 1976) and tested in 3 environments; field, greenhouse, and laboratory. The greenhouse and the field experiments tested emergence rate. The laboratory test was used to determine mortality due to seed treatment.

The greenhouse study began in December 1977 and lasted 8 weeks. The design used 5 randomized complete blocks in which 100 seeds per treatment were planted in a 35 cm row, with 10 rows in each 35.5 cm by 48.2 cm flat. The growing medium was a mixture of one part soil, one part peat moss, one part sand, and one part vermiculite. Greenhouse temperatures varied between 19°C and 26°C. Newly emerged seedlings were counted 14 days after planting and every 7 days thereafter. After each counting seedlings were removed to prevent confusion with subsequent counts.

The laboratory experiment began in February 1978 and continued for 12 weeks. In this time period 3 consecutive 4-week long replications were observed. One hundred seeds per treatment were placed on moist blotters in 11 cm by 11 cm by 2.4 cm plastic moisture boxes. The boxes were placed in a dark germination chamber set at 15°C. Germinated seeds (showing both radicle and hypocotyl emergence) were counted and removed every 7 days. Seeds that did not germinate after 28 days were bisected longitudinally and soaked in a 0.1% tetrazolium solution for 4 hours at 32°C. If a distinct pink-red color developed in the embryo, the seed was considered viable. Seeds showing no reaction were considered nonviable.

The field trial was planted in November, 1977, in disturbed soil in the Piceance Basin region of northwestern Colorado. The land was prepared by scraping all vegetation and some topsoil from the surface. The experimental design was a randomized complete block with 4 replications. In each replication, 400 seeds per treatment (3 ages of seed, 10 treatments per age) were planted in each of 30 3-m rows at approximately 2 cm depth. Prior to planting 22 kg of nitrogen (ammonium nitrate) and 22 kg of phosphorus (superphosphate) were applied per ha and incorporated into the soil. The field trial depended on natural precipitation (30.5 cm per year). No irrigation was applied even though a dry spell was experienced in June and July 1978, slowing seedling growth. Seedlings were counted in May 1978 and July 1978. May was chosen for the initial seed count because from previous experience initial spring emergence does not begin until late April-early May, (after spring thaw in the Piceance Basin region). Subsequent counts at 6 and 12 weeks were planned to determine late emergence and establishment. The third counting, planned for September 1978, was not done because the nursery was destroyed by rodents in the latter part of August.

Analyses of variance were conducted to determine significant differences among ages of seed, among types of treatments, and with the application of GA_3. An error level of $\alpha = .05$ was chosen for testing the significance of observed differences. Duncan's multiple range test was used to determine if there were significant differences between the treatments within each age group.

Table 1. Percent emergence in the greenhouse study.

Treatment	Two-year-old seed	One-year-old seed	Six-month-old seed
Control	50.2a[1]	28.0bc	8.4b
Commercial scarifier	70.2a	26.6bc	20.6b
Tumbler	64.5a	17.0c	10.0b
Rubbing machine	62.2a	23.8bc	4.6b
Sulfuric acid	66.4a	55.6a	52.6a
GA_3	62.4a	26.0bc	8.2b
Commercial scarifier + GA_3	49.4a	54.4a	39.4a
Tumbler + GA_3	50.8a	30.2bc	8.6b
Rubbing machine + GA_3	55.4a	30.3bc	10.2b
Sulfuric acid + GA_3	66.8a	30.9ab	50.2a

[1]Means in the same column are significantly different at ($\alpha = .05$ level) by Duncan's multiple range test if not followed by any letter in common.

Results and Discussion

Each of the 9 techniques to reduce seed dormancy was tested, with a control, on 3 ages of seed (6, 15, and 27 months) in the greenhouse and field for emergence, and the laboratory for mortality.

Greenhouse Emergence Study

Emergence of the untreated seed increased with age (Table 1), concurring with Rogler's (1960) findings on the effect of age on dormancy. Emergence also increased with age in 8 of the 9 treatments. Germination of seed treated with commercial scarifier plus GA_3 decreased, however, between 1- and 2-year-old seed. Emergence of the sulfuric acid plus GA_3 treated seed decreased from 6-month-old seed to 1-year-old seed but then increased, showing an overall increase with time.

No treatment of the 2-year-old seed affected germination (Table 1). Treatments involving sulfuric acid or the commercial scarifier plus GA_3 increased emergences of the 1-year old seed (Table 1). Emergence for all treatments was never significantly lower than that of the control. Emergence of the 6-month old seed treated with either sulfuric acid, commercial scarifier plus GA_3 or sulfuric acid plus GA_3 was greater than the 6-month-old control seed (Table 1).

Application of GA_3 did not affect emergence of 2-year old seed but did increase emergence for the 1-year-old and 6-month-old seed (Table 2). This result agrees with the findings of McDonald and Khan (1977).

Field Trial Emergence Study

Treatment response in the field contrasted greatly from that in the greenhouse (Table 3). The rubbing machine increased emergence of the 2-year-old seed 8.7 percentage points over its control (15% to 23.7%), the highest in the field trial. This treatment was the only treatment to significantly improve emergence of the 2-year-old seed. No treatment showed a significant increase in germination in either the 1-year-old or 6-month-old seed. Sulfuric acid and sulfuric acid plus GA_3 treated seed showed a decreased emergence at all 3 ages, in contrast to the results of the greenhouse test. This difference could be due to the extremely weakened seed covering not being able to remain intact over a winter of freezing and

Table 2. Percent emergence of treatments without GA_3 versus those with GA_3, in the greenhouse and the field studies.

Study	Treatment	Two-year-old seed	One-year-old seed	Six-month old seed
Greenhouse	No GA_3 applied	62.7a[1]	30.2b	18.2b
	GA_3 applied	57.0a	40.1a	23.3a
Field	No GA_3 applied	13.4a	11.8a	8.3a
	GA_3 applied	14.7a	12.2a	8.0a

[1]Means in the same column within a study are significantly different at $\alpha = .05$ level if not followed by any letter in common.

Table 3. Percent emergence in the field trial.

Treatment	Two-year-old seed	One-year-old seed	Six-month-old seed
Control	15.0bc[1]	13.5abc	8.2abc
Commercial scarifier	12.5cd	17.8a	10.2ab
Tumbler	10.0de	9.8c	8.5abc
Rubbing machine	23.7a	15.5ab	12.0a
Sulfuric acid	6.0ef	2.8d	3.0d
GA_3	18.0b	11.0bc	8.6abc
Commercial scarifier + GA_3	15.5bc	16.5a	12.8a
Tumbler + GA_3	15.5bc	14.0abc	8.8abc
Rubbing machine + GA_3	20.0ab	17.2a	5.8bcd
Sulfuric acid + GA_3	4.5f	2.5d	3.8cd

[1]Means in the same column are significantly different at $\alpha = .05$ level by Duncan's multiple range test if not followed by an letter in common.

thawing. Once the integrity of the seed covering is broken, soil pathogens could attack and kill the seeds.

There was no increase in average field emergence due to application of GA_3 for any of the seed ages (Table 2), also in contrast to the greenhouse test results.

The overall lower emergence of the field trial when compared to the greenhouse study may be partially due to the method of land preparation. In the preparation too much topsoil may have been removed, drastically reducing the fertility and water holding capacity of the soil, and leaving it more subject to crusting.

Laboratory Mortality Study

Although numerical differences for mortality among treatments occurred (Table 4), variation among replications rendered these differences nonsignificant. Thus no treatment significantly decreased viability of the seed used for planting.

Conclusions

In the many studies to improve Indian ricegrass germination, sulfuric acid to weaken the seed covering has been most effective (Huntamer 1934, Toole 1940, Stoddart and Wilkinson 1938, Plummer and Frischknecht 1952, McDonald and Khan 1977). The greenhouse test in this study supports this finding, but only for seed less than 2 years old. It is likely that for seed 2 years old, time has naturally reduced dormancy to a point at which treatment is inconsequential. The only problem is that one cannot always store seed for 2 years before needing to use it, especially in multiplying seed for new strains or testing breeding progenies.

In the field, no single treatment successfully increased germination of all ages of seed. Scarification by the rubbing machine did, however, increase germination of the 2-year-old seed. It is probable that use of the rubbing machine enhanced by overwintering (exposure to moist cold temperatures) can with good site preparation, increase germination for revegetation to an acceptable level.

In a subsequent field progeny test in the Piceance Basin topsoil was conserved and rototilling was done in the site preparation. Using the rubbing machine treatment on 6-month-old seed with fall planting, emergences of 35 to 50% were obtained.

Scarification by sulfuric acid decreased germination in the field for all 3 ages. It may be that the sulfuric acid weakened the seed covering so much that it could not survive overwintering. Sulfuric acid treated seed may do well for plantings in the spring but due to climatic conditions in the Piceance Basin region (early spring moisture) spring planting is difficult and does not take maximum

Table 4. Percent mortality in the laboratory germination box study.

Treatment	Two-year-old seed	One-year-old seed	Six-month-old seed
Control	6.3	4.0	9.0
Commercial Sacrifier	5.7	2.7	9.0
Tumbler	6.3	3.0	8.3
Rubbing machine	3.3	5.7	8.3
Sulfuric acid	2.7	8.3	10.0
GA_3	11.0	13.3	14.5
Commercial scarifier + GA_3	8.3	5.7	13.0
Tumbler + GA_3	8.0	8.3	9.7
Rubbing machine + GA_3	8.7	8.0	9.7
Sulfuric acid + GA_3	6.3	3.7	10.3

advantage of available moisture. A spring field progeny test similar to that mentioned above, but using a sulfuric acid treatment, was done in 1979. Emergence and stand establishment for the spring progeny test were poorer than the fall progeny test.

For seeds less than 2-years old, treatment with GA_3 appears to be beneficial. In younger seeds, hormonally induced dormancy is present and can be reduced with this hormone, gibberellic acid. As chemical dormancy is reduced by aging, GA_3 treatment of older seed is unnecessary.

These tests demonstrate an immediate solution to high seed dormancy in Indian ricegrass. Through breeding, a long term solution to dormancy may be obtained. As an example, 'Nezpar,' a recent release by the Soil Conservation Service, Aberdeen, Ida., has been described as having an improved establishment capability although its hard seed content ranges between 80 and 100% (Booth et al. 1980). In other tests, the authors have found Nezpar to have 8% fresh germination, compared to 5% for Paloma. The combination of breeding with scarification, where necessary, will make Indian ricegrass a valuable species for revegetation.

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