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Evaluation of Methods of Reducing Seed Dormancy in Switchgrass, Indiangrass, and Big Bluestem

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EVALUATION OF METHODS OF REDUCING SEED DORMANCY IN SWITCHGRASS, INDIANGRASS, AND BIG BLUESTEM

BY

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IN SWITCHGRASS, INDIANGRASS, AND BIG BLUESTEM

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

Switchgrass, Panicum virgatum L., Indiangrass, Sorghastrum nutans (L) Nash, and big bluestem, Andropogon gerardi Vitman, are tall, erect, native warm-season perennial grasses which in the past few years have received wide acceptance for use in the midsummer pasture establishment throughout the Great Plains. These warm-season grasses are native to the eastern part of the Great Plains and largely make up the tall grass prairie. They are well adapted to hot summer conditions and grow vigorously during July and August when the growth of cool-season grasses is slow or nil.

Stand establishment and laboratory seed testing of these grasses are complicated by high levels of seed dormancy which frequently persists a year or more after seed harvest.

Germination procedures set forth in the Association of Official Seed Analysts' Rules for Testing Seeds-1970 (2) prescribe a two-week prechill of dormant switchgrass, Indiangrass and big bluestem seed. Germination readings obtained when using the above method were low. The low germinating samples can be checked to determine actual viability and potential germination (3) with a triphenyl tetrazolium chloride solution. Tetrazolium tests indicated that many of the seed were capable of a germination and that the switchgrass, Indiangrass, and big bluestem seed were in a temporary state of dormancy.

This study was undertaken to see if pregermination treatment(s) would reduce the seed dormancy of switchgrass, Indiangrass, and big

bluestem in order to obtain maximum germination reading in the laboratory and in field plantings.

REVIEW OF LITERATURE

Seed Dormancy

Many times the seed of freshly harvested grains and grasses show delayed germination or dormancy. Dormancy, as defined in the Yearbook of Agriculture Seeds (19), "is an internal condition of the chemistry or stage of development of a viable seed that prevents its germination although good growing temperatures and moisture are provided."

Stone (27) tested rye, wheat, and timothy at 5-day intervals up to 20 days. Germination percentages were considerably higher after 20 days than at 5 days.

In his studies with green needlegrass, McWilliams (17) studied the effects of age on dormancy. He found a decrease in dormancy with increasing age of seed. Peak germination was reached at 7 years of age after which time there was a gradual decrease in germination for 21 years.

Shaidaee, Dahl, and Hanson (26) in their work with the germination and emergence of different age seeds found that the dormancy of Indiangrass was completely broken in 2-year-old seeds. They also reported that a 7-year-old lot of switchgrass seed germinated first, emerged first, and gave the highest final percentages.

Field Establishment

Laude (15) reported that there is evidence in certain range and pasture species that dormancy of fresh seed more frequently may persist long enough to interfere with good emergence rates during the first

planting season following harvest.

Coukos (7) noted such dormancy in Indiangrass, big and little bluestem, and some collections of sideoats grama. He stated "of the several peculiarities of native grass seeds, the character of dormancy is primary in influencing stand establishment."

In 1967, Rafii (20) investigated seed characters in relation to field establishment. He concluded that spikelet germination was more closely related and consistently correlated with field establishment than any other seed character.

Laboratory Methods

Geng and Barnett (12) reported that prechilling did not appear to remove all seed dormancy. They also stated "economic feasibility of prechilling as a practical means of improving Indiangrass establishment is questionable."

Low Temperature Soaking

Low temperature treatment has been recognized as an effective means of reducing seed dormancy in many species. Blake (5) reported that stratification of seeds of Indiangrass through the winter months resulted in a marked increase in germination. Barton (4) reported that, with some species, stratification was one of the best methods for inducing germination of seeds with dormant embryos. Kearns and Toole (13) found that good germination of fescue seed followed prechilling for seven days at 5° C. According to Crocker (8) low temperature treatment of imbibed seeds has commonly been used to induce after-ripening.

The leaching effect of water had been found effective in reducing seed dormancy in some species. Rogler (22) reported that seeds of green needlegrass and Indian ricegrass showed a marked increase in germination when soaked in water at 2-4° C for 20 and 40 days.

Musil (18) studied pretreatments of buffalograss for field plantings. The pretreatment which increased germination of buffalograss was soaking seed in tap water 48 hours, drying thoroughly at room temperature, and then prechilling at 5° C for 6 weeks.

Wenger (29) treated buffalograss to improve germination. He recommended soaking dormant seeds for 24 hours in 0.5 percent potassium nitrate, prechilling at 41° F for 6 weeks. After prechilling, seeds were dried at a temperature under 120° F. The germination of dormant buffalograss seed increased 75 percent with this treatment. A commercial plant, currently owned and operated by Sharp Brothers Seed Company (Healy, Kansas), treats buffalograss by this method to reduce dormancy (25).

High Temperature and Humidity

The effect of temperature and humidity on seed germination has been studied periodically. Coukos (7) in his work with native grass used various combinations of temperature and humidity. He found that low temperature and high humidity had a tendency to induce germination more rapidly than any other temperature-humidity relationship, but the difference was not significant.

In his work with storability of seed, Delouche (11) found that temperatures of 40-45° C and 100 percent relative humidity for 2 to 8

days caused accelerated aging of crimson clover, alfalfa, tall fescue, and sorghum. He states that "the deteriorative processes in seed progresses to a certain point or degree, which is not known, before the seeds lose their capacity for normal germination."

High Temperature

Leopold (16) writes that high temperature has been found to increase seed dormancy rather than reduce it. However, Ahring, Dunn, and Harlan (1) found that preheating seed of sand lovegrass for 30 or 40 minutes at 90-100° C was somewhat effective in breaking dormancy. Preheating for periods of 12 to 24 hours at 50-60° C was also quite effective.

Sun (28) found that the exposure of Indiangrass to temperatures of 90-100° C for 30, 45, 75, and 90 minutes did not significantly reduce germination of some lots.

Hull Removal

Removal of the chaffy coverings of the caryopsis has been shown effective in reducing seed dormancy in a number of grasses. As early as 1906, Crocker (8) used wild oats seed to show that the seed coats of grasses affect germination.

Ray and Stewart (21) and Barton (4) found hulling effective in increasing germination of several species of Paspalum.

Dawson and Heinricks (10) reported increased seed germination following complete removal of the lemma and palea of green stipagrass.

According to Wiesner (30), removal of seed coats of green

needlegrass increased germination over the standard germination procedures but did not equal tetrazolium readings.

Canode, Horning, and Maguire (6) reported that removal of the lemma and palea in the threshing process gave a significant increase in germination of orchardgrass seed.

Clipping

In Kinch's (14) study to induce rapid germination of western wheatgrass, he found that clipping off the caryopsis tip increased germination of some seed lots.

Wiesner (30) found clipping of the green needlegrass caryopsis tip increased germination over the standard germination procedures but did not equal tetrazolium readings.

Freezing

Coukos (7) stored Indiangrass, big and little bluestem, sideoats grama, and bromegrass in different type containers and under different environmental conditions. He concluded that cold storage (0-5° C) in a bag shortened the life span of the seeds after dormancy was broken. Cold storage conditions prolonged dormancy of Indiangrass but once the dormancy was broken, the viability of the seeds was sharply reduced.

In Sautter's (24) work with switchgrass, he found that seeds held at freezing temperatures for 54 days did not increase or decrease its germination.

MATERIALS AND METHODS

Seed Collection

Seed collections of switchgrass, Indiangrass, and big bluestem were made in the fall of 1971 and 1972.

September 1971

Three varieties of switchgrass seed were collected from the South Dakota State University Experiment Station grass nursery; Summer, South Dakota 30, and Nebraska 28. The variety Summer was also obtained from the Foundation Seed Stock 1971 harvest. Indiangrass seed was collected at the grass nursery only. Three big bluestem seed collections were made at (1) the grass nursery, (2) Oak Lake, South Dakota, and (3) northeast of Elk Point, South Dakota.

September 1972

Switchgrass seed was collected at the grass nursery and from an ungrazed switchgrass pasture on the South Dakota State University Dairy Farm. Indiangrass seed collections were made at the grass nursery and from railroad frontages four miles west of Brookings, South Dakota. Big bluestem seed collections were made at the grass nursery and from a pasture two miles south of Brookings.

All material, except the Foundation harvest, was hand collected and threshed. All of the collections were hand cleaned and tested for germination. Each seed lot was divided in half by a Gamet divider and placed into manila envelopes. The seed was stored at 25° C and -23° C.

Sampling

Switchgrass generally threshes free of glumes and attached sterile florets with normal handling. Therefore, individual seeds can be counted for tests. Germination tests for switchgrass involved samples of 400 randomly selected seeds. The Indiangrass and big bluestem spikelet possesses one perfect and one staminate flower or floret and is normally capable of producing only one caryopsis. Therefore, germination tests for Indiangrass and big bluestem involved the sampling of 400 randomly selected spikelets.

Hereafter, the seed unit of switchgrass and the spikelets of Indiangrass and big bluestem shall be referred to as seeds.

Germination

Germination tests were made to determine the germination and the amount of dormant seed present. Germination procedures used were those written in the Rules for Testing Seeds-1970 (2). The rules recommend that four 100 seed lots each be placed in a covered dish containing two blotters moistened with 0.2 percent potassium nitrate (KNO_3) solution. Spergon[1] was sprinkled on the seeds to inhibit mold. Two seed lots were placed in 15-30° C germinator[2] for 28 days. At the end of 28 days, those seeds producing a normal shoot and root were counted. The average of

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[1]Hereafter, spergon shall refer to a fungicide. It has the coined name of CHLORANIL and the chemical name of Tetrachloroquinone.

[2]Hereafter, 15-30° C temperature will refer to 8 hours at the higher temperature and 16 hours at the lower temperature unless otherwise specified with light being supplied at the higher temperature.

those two lots shall hereafter be referred to as normal (N) germination. The other two seed lots were placed in 5° C refrigerator for two weeks and then placed in the 15-30° C germinator for 28 days. At the end of 28 days, those seeds producing a normal shoot and root were counted. The average of those two lots shall hereafter be referred to as prechill (PC) germination.

A tetrazolium viability test (TZ) was used on the ungerminated seeds of some lots, as described in the Tetrazolium Testing Handbook (3). The ungerminated seeds were bisected longitudinally exposing the main structures of the embryo. One-half of the seed was then immediately placed into a dish containing tetrazolium solution.[1] At the end of four hours, the embryos were examined for a normal red color. The number of red embryos were counted and recorded. A figure for total viable seed (TVS) was then obtained by adding the tetrazolium reading to the germination percentage.

Pregermination Treatments

Samples of 100 randomly selected seeds of switchgrass and samples of 100 randomly selected spikelets of Indiangrass and big bluestem were used in all of the pregermination treatments. After each pregermination treatment, the samples were planted according to the Rules for Testing Seeds-1970. Spergon was added to deter fungus growth.

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[1]Hereafter, the tetrazolium solution shall refer to a 0.5 percent 2,3,5-triphenyl tetrazolium chloride salt solution.

After 28 days, the seeds producing a good shoot and root were counted and recorded. In some tests, the ungerminated seeds were tested for viability. Normal and prechill germinations were used as the check.

Low Temperature Soaking

Twenty samples of freshly harvested switchgrass, Indiangrass, and big bluestem were placed in 2-inch by 3-inch cotton bags and tied shut with a string. Each sample was submerged in a beaker of 0.2 or 0.5 percent potassium nitrate solution, held at 5° C, for 24 or 48 hours. The samples were removed from the solution, drained, and left in a moist condition at 5° C for a period of 2, 4, or 6 weeks. Selected samples were resoaked for 24 hours in the potassium nitrate solution at the end of 2 and/or 4 weeks. After soaking and chilling, the samples were dried in a 35° C oven for 24 hours, removed from the cotton bags, and planted.

High Temperature and Humidity

Five samples each of freshly harvested switchgrass, Indiangrass, and big bluestem were placed in cones made from 4-inch filter papers. The cones were placed in the tray inside the high humidity chamber. The high humidity chambers were sealed glass desiccators. The desiccator well was filled with water and a tray with five holes placed over it. Vaseline was rubbed on the desiccator rim before putting the lid in place. The desiccator was placed in a 40° C germinator to form the high temperature-high humidity chamber. One, two, three, four, and five days later, the seeds were removed from the cones and planted.

High Dry Temperature

Eight samples each of freshly harvested switchgrass, Indiangrass, and big bluestem were placed in 2-inch by 3-inch coin envelopes. The envelopes were placed in a 100° C oven for periods of 5, 10, 15, 20, 25, 30, 40, 50, and 60 minutes. The seeds were then immediately removed from the coin envelopes and planted.

Dehulling

Four samples each of 6-month-old switchgrass, Indiangrass, and big bluestem were placed on a rub board and rubbed free of all outer appendages, leaving only the caryopses. The caryopses were planted under normal and prechill germination conditions.

Clipping

Four samples each of 6-month-old switchgrass, Indiangrass, and big bluestem had the dorsal tip cut from the caryopsis with a razor blade. The clipped caryopses were planted under normal and prechill germination conditions.

Freezing

After one year switchgrass, Indiangrass, and big bluestem seeds were removed from the -23° C freezer and planted.

EXPERIMENTAL RESULTS

Seed Collection

1971

An adequate supply of switchgrass seed for pregermination treatments was obtained from two sources: the variety South Dakota 30 from the grass nursery and the variety Summer from the Foundation Seed Stock harvest. Only a small supply of the variety Nebraska 28 was collected, so it was used in only one study. The Summer switchgrass collected at the grass nursery had shattered before collection and therefore, this supply was not saved.

The Indiangrass seed collected at the grass nursery provided an ample quantity of good quality seed to use for experiments.

Big bluestem seed harvested at the grass nursery was the only lot which provided ample seed to work with. It was very difficult to find fertile florets of the big bluestem collected at Oak Lake; therefore, the time was not taken to get a large quantity of seed. The Elk Point collection was discarded because no fertile florets could be found.

1972

All switchgrass, Indiangrass, and big bluestem collected at the grass nursery provided an ample quantity of good quality seed to use for pregermination treatments.

Only very small quantities of seeds were collected at the dairy farm, railroad frontage, and pasture sites; therefore, only an initial germination test would be made on these collections.

Germination

Germination percentages of freshly harvested switchgrass, Indiangrass, and big bluestem seed, as shown in Table 1, indicated that there was a high degree of dormancy present. Tetrazolium readings were taken to indicate the actual viability of the seed in each lot.

The amount of seed dormancy did not vary much between the 1971 and 1972 harvests. Prechilling the seed improved the germination of all lots, but the tetrazolium readings indicated that the seed was capable of a much higher germination. The Summer switchgrass had the least amount of dormancy, but it was tested two months later than the other lots. It was also machine harvested which could have an effect on dormancy.

The seed supply and the results of the germination tests warranted the use of the following lots in pregermination treatments to break dormancy.

1971	1972
- S.D. 30 switchgrass	- nursery switchgrass
- nursery Indiangrass	- nursery Indiangrass
- nursery big bluestem	- nursery big bluestem

Germination tests using different substrates and moistening agents were conducted to see if the procedures written in the Rules for Testing Seeds-1970 were the best for germination tests. Blotters as a substrate and 0.2 percent potassium nitrate moistening agent gave the best germinations for all three grasses as shown in Table 2.

Table 1. Germination Percentages of Freshly Harvested Switchgrass, Indiangrass, and Big Bluestem Seed in a 15-30° C Germinator.

Seed Type	Germination Percentages (N)	(PC)	Tetrazolium Reading of 100 Seeds
1971			
Switchgrass			
S.D. 30	11	42	98
Neb. 28	20	51	98
Summer	25	81	98
Indiangrass			
Nursery	7	20	93
Big bluestem			
Nursery	6	45	94
1972			
Switchgrass			
Nursery	7	41	98
Dairy	22	52	97
Indiangrass			
Nursery	2	19	96
Railroad	0	18	95
Big bluestem			
Nursery	7	43	92
Pasture	4	48	90

Table 2. Germination Percentages of Four Month Old Switchgrass, Indiangrass, and Big Bluestem Seed in a 15-30° C Germinator Using Different Substrates and Moistening Agents. 1971 Harvest.

Seed Type	Substrate	Germination Percentage	Moistening Agent	Germination Percentage
SWITCHGRASS	Blotter	27	0.2 KNO_3	29
	Kimpack	19	Water	26
INDIANGRASS	Blotter	28	0.2 KNO_3	23
	Kimpack	23	Water	12
BIG BLUESTEM	Blotter	44	0.2 KNO_3	33
	Kimpack	27	Water	23

Pregermination Treatments

Low Temperature Soaking

Preliminary tests on the 1971 seed collections of switchgrass, Indiangrass, and big bluestem seed were conducted using the procedure outlined by Wenger (29) in breaking dormancy of buffalograss. The tests revealed that additional studies may be warranted. Therefore, variations of the buffalograss treatment were set up as shown in Tables 3, 4, and 5. The switchgrass, Indiangrass, and big bluestem seeds were then subjected to the different treatments: Tables 3, 4, and 5.

Table 3. Germination Percentages of Freshly Harvested Switchgrass in a 15-30° C Germinator After Receiving Pretreatments Involving the Combinations of Prechilling, KNO_3 Concentration, Soaking and Resoaking. 1971 Seed Harvest.

Sample Number	Weeks of Prechill	KNO_3 Conc.	Soaking Hours	Resoak	Germination Percentage
Control (N)					11
Control (PC)					42
1	2	0.2	24		44
2	2	0.2	48		25
3	2	0.5	24		23
4	2	0.5	48		26
5	4	0.2	24		41
6	4	0.2	24	X	44
7	4	0.2	48		31
8	4	0.2	48	X	46
9	4	0.5	24		37
10	4	0.5	24	X	40
11	4	0.5	48		45
12	4	0.5	48	X	40
13	6	0.2	24		46
14	6	0.2	24	X	51
15	6	0.2	48		37
16	6	0.2	48	X	33
17	6	0.5	24		32
18	6	0.5	24	X	30
19	6	0.5	48		27
20	6	0.5	48	X	29

All switchgrass seed treatments (Table 3) increased the germination when compared to the normal germination of 11%. Only sample numbers 1, 6, 8, 11, 13, and 14 germinated higher than the prechill germination of 42%. None of the samples came close to its potential as indicated by the tetrazolium reading of 98%.

Similar results were obtained when the same experimental procedures were used on varieties Nebraska 28 and Summer.

Table 4. Germination Percentages of Freshly Harvested Indiangrass in a 15-30° C Germinator After Receiving Pretreatments Involving the Combinations of Prechilling, KNO_3 Concentration, Soaking and Resoaking. 1971 Seed Harvest.

Sample Number	Weeks of Prechill	KNO_3 Conc.	Soaking Hours	Resoak	Germination Percentage
Control (N)					29
Control (PC)					61
1	2	0.2	24		8
2	2	0.2	48		5
3	2	0.5	24		54
4	2	0.5	48		11
5	4	0.2	24		44
6	4	0.2	24	X	46
7	4	0.2	48		43
8	4	0.2	48	X	41
9	4	0.5	24		16
10	4	0.5	24	X	27
11	4	0.5	48		38
12	4	0.5	48	X	22
13	6	0.2	24		0
14	6	0.2	24	X	27
15	6	0.2	48		16
16	6	0.2	48	X	20
17	6	0.5	24		8
18	6	0.5	24	X	14
19	6	0.5	48		18
20	6	0.5	48	X	11

Indiangrass seed (Table 4) samples 3, 5, 6, 7, 8, and 11 germinated better than the recorded normal germination of 29%. None of the samples germinated better than the prechill germination of 61%. Sample 3, with a germination of 54, came the closest to its potential germination of 93%.

Indiangrass seed was not tested again by this procedure.

Table 5. Germination Percentages of Freshly Harvested Big Bluestem in a 15-30° C Germinator After Receiving Pretreatments Involving the Combinations of Prechilling, KNO_3 Concentration, Soaking and Resoaking. 1971 Seed Harvest.

Sample Number	Weeks of Prechill	KNO_3 Conc.	Soaking Hours	Resoak	Germination Percentage
Control (N)					26
Control (PC)					76
1	2	0.2	24		68
2	2	0.2	48		54
3	2	0.5	24		38
4	2	0.5	48		58
5	4	0.2	24		48
6	4	0.2	24	X	57
7	4	0.2	48		60
8	4	0.2	48	X	62
9	4	0.5	24		44
10	4	0.5	24	X	54
11	4	0.5	48		44
12	4	0.5	48	X	46
13	6	0.2	24		68
14	6	0.2	24	X	75
15	6	0.2	48		44
16	6	0.2	48	X	81
17	6	0.5	24		72
18	6	0.5	24	X	21
19	6	0.5	48		46
20	6	0.5	48	X	17

Big bluestem seed (Table 5) samples were all above the normal germination of 26% except numbers 18 and 20. Sample 16 surpassed the prechill germination of 76% by 5% and was only 13% from its potential germination of 94%. Duplication of the treatment given to sample 16 failed to give similar results.

Big bluestem seed was not tested again by this procedure.

High Temperature and Humidity

A preliminary test on dormant hard red winter wheat was conducted using procedures similar to those outlined by Delouche (11) for testing the storability of seeds. The accelerated aging technique gave very positive results on the dormant wheat, as shown in Table 6.

Table 6. Germination Percentages of Hard Red Winter Wheat in 20° C Germinator After Receiving Pretreatment of 1, 2, 3, 4, and 5 Days in High Temperature and Humidity 40° C - 95% R.H. Chamber.

Days in Chamber	Germination Percentage
0	75
1	96
2	77
3	23
4	8
5	2

One day in the chamber caused the germination of the hard red winter wheat to increase from 75% to 96%. After that the number of abnormal and dead seeds increased indicating that the high temperature and humidity was harmful to the seeds.

The same procedure was used on eleven month old switchgrass, Indiangrass, and big bluestem seed which had been stored at -23° C to retain its dormancy. Tables 7, 8, and 9 show the results.

Table 7. Germination Percentages of Eleven Month Old Switchgrass Seed in a 15-30° C Germinator After Receiving Pretreatment of 1, 2, 3, 4, and 5 Days in High Temperature and Humidity 40° C - 95% R.H. Chamber.

Days in Chamber	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	9	76	85
1	4	78	82
2	6	68	74
3	3	71	74
4	9	58	67
5	8	55	63

The treated switchgrass seeds (Table 7) germinated less than the control of 9%. The total number of seeds germinated in some samples increased with the length of treatment, but the number of total viable seeds decreased from 85% to 63%.

Table 8. Germination Percentages of Eleven Month Old Indiangrass Seed in a 15-30° C Germinator After Receiving Pretreatment of 1, 2, 3, 4, and 5 Days in High Temperature and Humidity 40° C - 95% R.H. Chamber.

Days in Chamber	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	5	52	57
1	6	52	58
2	11	40	51
3	11	35	46
4	10	32	42
5	7	32	39

The treated Indiangrass seed (Table 8) germinated 6% better than the control of 5% after 2 and 3 days in the chamber. However, the total viable seed decreased from 57% to 46% after 3 days. At the end of 5 days, there was only 39% total viable seed remaining.

Table 9. Germination Percentages of Eleven Month Old Big Bluestem Seed in a 15-30° C Germinator After Receiving Pretreatment of 1, 2, 3, 4, and 5 Days in High Temperature and Humidity 40° C - 95% R.H. Chamber.

Days in Chamber	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	46	30	76
1	28	42	70
2	22	50	72
3	29	41	70
4	13	50	63
5	7	54	61

The treated big bluestem seed (Table 9) did not germinate better than the control of 46%. One day in the chamber decreased the germination 18% and after 5 days, there was a decrease of 39%. The total viable seed decreased 15% over the 5-day period.

Although the results obtained from the experiments in Table 7, 8, and 9 were not promising, it was decided to test freshly harvested seed in the same manner. Results of high temperature and humidity on freshly harvested seeds are shown in Tables 10, 11, and 12.

Table 10. Germination Percentages of Freshly Harvested Switchgrass Seed in a 15-30° C Germinator After Receiving Pretreatment of 1, 2, 3, 4, and 5 Days in High Temperature and Humidity 40° C - 95% R.H. Chamber.

Days in Chamber	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	7	85	92
1	11	65	76
2	13	73	86
3	1	69	70
4	37	35	72
5	2	65	67

The pretreated switchgrass seed (Table 10) gave erratic results. After 2 days in the chamber, germination increased from 7% to 13%. One day in the chamber and the germination was only 1%, but after 4 days the germination was up to 37%, 30% better than the control. The total viable seed dropped from 92% to 72%.

Table 11. Germination Percentages of Freshly Harvested Indiangrass Seed in a 15-30° C Germinator After Receiving Pretreatment of 1, 2, 3, 4, and 5 Days in High Temperature and Humidity 40° C - 95% R.H. Chamber.

Days in Chamber	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	20	68	88
1	25	62	87
2	41	44	85
3	30	55	85
4	37	48	85
5	48	35	83

The pretreated Indiangrass seed (Table 11) germinated better than the control of 20%. After 5 days in the chamber, the germination was 28% better and there was only a decrease of 5% total viable seed.

Table 12. Germination Percentages of Freshly Harvested Big Bluestem Seed in a 15-30° C Germinator After Receiving Pretreatment of 1, 2, 3, 4, and 5 Days in High Temperature and Humidity 40° C - 95% R.H. Chamber.

Days in Chamber	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	38	54	92
1	33	50	83
2	20	47	67
3	27	43	70
4	31	34	65
5	35	28	63

The pretreated big bluestem seed (Table 12) germinated less than the control of 38%. After 2 days the germination was down 18%, but after 5 days it was only 3% less than the control. There was a decrease of 15% in total viable seed after 2 days, but after 3 more days it only dropped 4% more.

High Temperature

An experiment was designed to test the effect of high temperatures on breaking the dormancy of switchgrass, Indiangrass, and big bluestem seed. Eleven month old seed stored at -23° C was placed in an 100° oven for periods of 5, 10, 15, 20, 30, 40, 50, and 60 minutes and then

germinated. Tables 13, 14, and 15 show the results.

Table 13. Germination Percentages of One Year Old Switchgrass Seed in a 15-30° C Germinator After Receiving a Pretreatment of 5, 10, 15, 20, 30, 40, 50, and 60 Minutes in an Oven 100° C.

Minutes in Oven	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	9	76	85
5	5		
10	4		
15	6		
20	6		
30	16	33	49
40	12		
50	3		
60	3		

The 30-minute treatment of switchgrass seed (Table 13) increased the germination 7% over the control of 9%. At the end of 60 minutes, the germination was 6% less than the control. A tetrazolium reading of the best germination (30-minute treatment) revealed that the total viable seed had decreased by 36%.

The 40-minute treatment of Indiangrass seed (Table 14) increased the germination 13% over the control of 5%. At the end of 50 minutes, the germination was 0. A tetrazolium reading of the highest germination (40-minute treatment) revealed that the total viable seed had decreased by 21%.

Table 14. Germination Percentages of One Year Old Indiangrass Seed in a 15-30° C Germinator After Receiving a Pretreatment of 5, 10, 15, 20, 30, 40, 50, and 60 Minutes in an Oven 100° C.

Minutes in Oven	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	5	52	57
5	16		
10	12		
15	7		
20	12		
30	8		
40	18	18	36
50	0		
60	9		

All of the treatments on big bluestem (Table 15) failed to give germinations above the control of 46%. A germination of 28% after 15 minutes was the highest reading and it was 18% below the control. A tetrazolium reading revealed that the total viable seed decreased 18% after 15 minutes.

Although the results obtained from the experiments shown in Tables 13, 14, and 15 did not increase germination appreciably, it was decided to test freshly harvested seed in the same manner. Results of the high heat treatment on the freshly harvested seeds are shown in Tables 16, 17, and 18.

Table 15. Germination Percentages of One Year Old Big Bluestem Seed in a 15-30° C Germinator After Receiving a Pretreatment of 5, 10, 15, 20, 30, 40, 50, and 60 Minutes in an Oven 100° C.

Minutes in Oven	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	46	30	76
5	13		
10	20		
15	28	10	38
20	21		
30	13		
40	19		
50	19		
60	8		

The germination of switchgrass seed (Table 16) increased with treatments through 50 minutes. The 50-minute treatment was 11% higher than the control of 7% but the tetrazolium reading revealed that the total viable seed decreased by 46%.

The treated Indiangrass seed (Table 17) increased with each time period. The germination after 5 minutes decreased 11% from the control of 20%, but then the germination increased to 26% after the 60-minute treatment. The total viable seed decreased 29% after 60 minutes.

Table 16. Germination Percentages of Freshly Harvested Switchgrass Seed in a 15-30° C Germinator After Receiving a Pretreatment of 5, 10, 15, 20, 30, 40, 50, and 60 Minutes in an Oven 100° C.

Minutes in Oven	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	7	85	92
5	5		
10	2		
15	6		
20	15		
30	11		
40	15		
50	18	28	46
60	12		

Table 17. Germination Percentages of Freshly Harvested Indiangrass Seed in a 15-30° C Germinator After Receiving a Pretreatment of 5, 10, 15, 20, 30, 40, 50, and 60 Minutes in an Oven 100° C.

Minutes in Oven	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	20	68	88
5	9		
10	14		
15	11		
20	12		
30	24		
40	21		
50	25		
60	26	33	59

Table 18. Germination Percentages of Freshly Harvested Big Bluestem Seed in a 15-30° C Germinator After Receiving a Pretreatment of 5, 10, 15, 20, 30, 40, 50, and 60 Minutes in an Oven 100° C.

Minutes in Oven	Germination Percentage	Tetrazolium Reading	Total Viable Seed
0	38	54	92
5	58		
10	57		
15	61		
20	60		
30	66		
40	70	10	80
50	64		
60	66		

All treatments of big bluestem seed (Table 18) had a higher germination than the control. The 5-minute treatment increased the germination from 38% to 58%, but the total viable seed went from 92% to 79%. The other treatments had germinations in the 60-70% range with the total viable seed remaining in the 70-80% range.

Hull Removal

Sun (28) reported that removing the hulls from Indiangrass will break some of its dormancy. This technique was used on the 1971 switchgrass, Indiangrass, and big bluestem to see if similar results could be obtained. The six month old seed gave the results shown in Table 19.

Hull removal of switchgrass increased germination from 27% to 44%. Indiangrass seed germination increased from 28% to 47%. Big bluestem seed germination increased from 44% to 52%.

Table 19. Germination Percentages of 6 Month Old Switchgrass, Indiangrass, and Big Bluestem Seed in a 15-30° C Germinator After Receiving Pretreatment of Hull Removal and Clipping.

Seed Type	Treatment	Germination Percentage
SWITCHGRASS	Control	27
	Hull Removed	44
	Clipped	22
INDIANGRASS	Control	28
	Hull Removed	47
	Clipped	34
BIG BLUESTEM	Control	44
	Hull Removed	52
	Clipped	52

Clipping

Kinch (14) and Wiesner (30) clipped the caryopsis tip in order to break the dormancy of cool-season native grasses. Their technique was used on the 1971 switchgrass, Indiangrass, and big bluestem seed to see if similar results could be obtained. The six month old seed gave the results shown in Table 19.

The clipped seed of switchgrass had a germination decrease of 5%. Indiangrass seed had a 6% germination increase. Big bluestem seed had an 8% germination increase.

Table 20. Germination Percentages of Thirteen Month Old Switchgrass, Indiangrass, and Big Bluestem Seed in a 15-30° C Germinator After Being Stored at 25° C and -23° C.

Seed Type	Storage Temp.	Germination Percentage		Tetrazolium Reading		Total Viable Seed	
		N	PC	N	PC	N	PC
SWITCHGRASS	25° C	88	85	4	3	92	88
	-23° C	27	45	54	30	81	75
INDIANGRASS	25° C	30	38	25	13	55	51
	-23° C	10	17	44	41	54	58
BIG BLUESTEM	25° C	69	73	4	6	73	79
	-23° C	59	74	29	1	88	75

Freezing

Switchgrass, Indiangrass, and big bluestem seed were stored in a -23° C freezer to see if the cold temperature had an effect on dormancy. Samples were removed after 13 months and planted. The results are shown in Table 20.

The switchgrass seed stored at 25° C had a normal germination of 61% more than the seed stored at -23° C. The prechill germination of the seed stored at 25° C was 40% more. There was 11% more total viable seed for both normal and prechill germinations of 25° C stored seed compared to the seed stored at -23° C.

The Indiangrass seed stored at 25° C had a normal germination of 20% more for the seed stored at -23° C. The prechill germination was 21% more for the seed stored at room temperature. There was virtually no difference in the total viable seed from each storage temperature.

The big bluestem seed stored at 25° C had a normal germination of 19% more than the seed stored at -23° C. The prechill germination and total viable seed were virtually the same for both storage conditions.

DISCUSSION

This study on dormancy in switchgrass, Indiangrass, and big bluestem seed was undertaken with three objectives. The primary objective was to find a pregermination treatment which would effectively break the dormancy of the three grasses. One of the secondary objectives was to find a pregermination treatment applicable to commercial use. The third objective was to develop a treatment which would give laboratory results showing the seeds full germination potential.

The buffalograss seed treatment, Wenger (29), of soaking the seed in a potassium nitrate solution at a low temperature with subsequent drying is effective in greatly reducing dormancy in that particular species. This pretreatment is now commercially used at the Sharp Brothers seed plant in Healy, Kansas (25). This system and many variations of it were tested on switchgrass, Indiangrass, and big bluestem. Several of the investigated treatments gave an increase in germination.

A technique to speed the aging process may be effective in reducing dormancy. Delouche's (11) accelerated aging technique (high temperature and humidity) was very effective on the dormant hard red winter wheat. The same procedure used on the dormant grasses resulted in increased germination.

Subjecting seed lots to a high temperature for varying lengths of time could be adapted to commercial use if the method would effectively break the seed's dormancy. Seeds placed in a 100^{o} C oven for

periods of 5 minutes to 60 minutes, showed increased germination of the switchgrass, Indiangrass, and big bluestem.

Hull removal and clipping of the caryopsis tip as methods of overcoming seed dormancy of switchgrass, Indiangrass, and big bluestem were studied primarily as methods of increasing laboratory germination readings. The two methods gave higher germinations than the control, but it was observed that there was also an increased number of abnormal sprouts.

Switchgrass, Indiangrass, and big bluestem seed lots were stored for 13 months at 25° C and -23° C to study the storage effects on dormancy. Seeds stored at the 25° C storage increased germination from 11% to 88%, the Indiangrass germination from 7% to 30% and the big bluestem germination from 6% to 69%.

Seed stored for the same length of time at -23° C showed switchgrass germination increasing from 11% to 27%; Indiangrass germination increasing from 7% to 10%; big bluestem germination increasing from 6% to 59%. In comparison, the 25° C storage reduced seed dormancy the greatest for switchgrass and Indiangrass. Big bluestem dormancy was reduced about the same under the two storage conditions.

The effectiveness of a pregermination treatment to break seed dormancy could be evaluated in different ways. The complete removal of seed dormancy would be the most effective treatment. A treatment resulting in an increased germination could also be considered an effective treatment. Data from the preceding section indicate that the pregermination treatments investigated were not capable of removing

all seed dormancy. However, there was an increased germination following some of the treatments. The data also indicated that there was a reduction in total viable seed as a result of the pregermination treatments. The germination results following a pregermination treatment would then be caused by a dormancy reducing factor and a viability reducing factor. The effectiveness of a pregermination treatment would then depend upon how much the caryopsis is disrupted by the two factors.

CONCLUSIONS

The tetrazolium reading on ungerminated seed was used to indicate seed viability and to determine residual seed dormancy after pregermination treatments. The end effect of a pregermination treatment is dependent upon the relationship of two factors (1) dormancy reducing factor (increase in germination), (2) viability reducing factor (reduction in total viability).

Switchgrass seed soaked in 0.2 percent potassium nitrate solution for 24 hours followed by a 6-week prechill increased germination by 40%. Indiangrass seed soaked in a 0.5 percent potassium nitrate solution for 24 hours followed by a 2-week prechill increased germination by 25%. Big bluestem seed soaked in 0.2 percent potassium nitrate solution for 48 hours followed by a 6-week prechill increased germination by 55%.

Four days in the high temperature and humidity 40° C - 95% R.H. chamber increased switchgrass germination 30% and decreased total viable seed by 20%. Five days in the same chamber increased Indiangrass germination by 28% and decreased total viable seed by 5%. Big bluestem seed germination was not increased and the total viable seed decreased 29% after 5 days.

Fifty minutes in a 100° C oven increased switchgrass germination 11% and decreased total viable seed 46%. Sixty minutes in the oven increased Indiangrass germination 6% and decreased total viable seed 29%. Fifteen minutes in the oven increased big bluestem germination 26% and decreased total viable seed 12%.

Hull removal increased switchgrass germination by 17%, increased Indiangrass germination by 19%, and increased big bluestem germination by 8%.

Clipping the caryopsis tip decreased switchgrass germination by 5%, increased Indiangrass germination by 6%, and increased big bluestem germination by 8%.

Thirteen months storage at 25° C increased switchgrass germination 77% and decreased total viable seed 6%. Indiangrass germination was increased 23% with a 38% decrease in total viable seed. Big bluestem germination was increased 63% with a 21% decrease in total viable seed.

Thirteen months storage at -23° C increased switchgrass germination 13% and decreased total viable seed 17%. Indiangrass germination was increased 3% with a 39% decrease in total viable seed. Big bluestem germination was increased 53% with a 6% decrease in total viable seed.

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