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Prechilling Switchgrass Seed on Farm to Break Dormancy

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Switchgrass (*Panicum virgatum* L.) is a warm-season, perennial bunch-type grass native to the North American Tallgrass Prairie. It has been investigated as a renewable energy crop due to its high productivity across a wide geographic range including various environmental conditions and soil types. Switchgrass has also been used for erosion control, summer grazing in pasture and hay systems for cattle, native prairie restoration, wildlife habitat, fiber production, and as an ornamental grass. Additional characteristics that make switchgrass an ideal renewable energy crop include ability to establish on marginal-quality land, low water and nutrient requirements, relatively easy planting and establishment, and compatibility with conventional farming equipment for establishment and harvest.

Failure to establish a productive switchgrass stand in a timely manner reduces the economic viability of switchgrass as a renewable energy crop. Possible reasons for poor stand establishment include unfavorable environmental conditions, planting seed too deep, excess weed competition, poor seed quality, and seed dormancy.

Rapid and uniform germination is important in successfully and cost-effectively establishing switchgrass stands. As with many native perennial grasses, switchgrass often has a high proportion of dormant seed, up to 95 percent, after harvest. Seed dormancy is a plant reproductive strategy that increases survivability in the wild. Switchgrass seed varies in the degree of dormancy, causing some seed to germinate when growing conditions are favorable and some to remain dormant as a backup reserve. To overcome erratic germination, producers can follow procedures to break seed dormancy and increase the germination percentage to improve stand establishment.

Figure 1. Switchgrass seed (Robert Geneve, University of Kentucky).

Techniques to Break Dormancy

Techniques that can be used to break switchgrass seed dormancy include storage, dormant seeding, and prechilling. Properly stored switchgrass seed will naturally decrease in dormancy. This process can take 2 to 4 years to obtain sufficient germination levels and could reduce seed viability.

Dormant seeding is planting switchgrass seed in late November or December. During the winter, the seed experiences cold, moist soil conditions that break seed dormancy. However, seeding rates should be increased for dormant seeding to be effective, since weather conditions are variable and can cause inconsistent dormancy release. Excess weed competition may also suppress switchgrass seedlings in the spring. The simplest and most efficient method to break dormancy is prechilling. Prechilling is the process of artificially subjecting seed to cold and moist conditions similar to the conditions seeds naturally experience over winter.

The benefit of artificially prechilling seed, instead of dormant seeding, is having the capability of performing germination tests to determine the effectiveness of the procedure. Producers can conduct a simple germination test to determine the germination percentage of the switchgrass seed before and after treatment to see how much of the seed broke dormancy as a result of the prechill treatment. However, producers are encouraged to submit switchgrass seed to the Seed Testing Laboratory at the University of Kentucky for germination testing due to the increased accuracy and consistency of the test results. (See References for details.)

A prechill treatment is recommended when the seed germination percentage is 40 percent and lower, especially when a large number of firm, ungerminated seeds remain at the end of the simple germination test.

Simple Germination Test Method ("Ragdoll" Test)

Modified procedure from Wolf and Fiske

Use a firm brown paper towel or its equivalent. Do not use the soft, absorbent paper towels made for kitchen use. Kitchen paper towels allow roots and shoots to penetrate the fibers, making removing the seedlings difficult.

Wet the brown paper towel, squeeze hard to remove excess water, and lay flat. Count 100 randomly selected seeds and place in rows on one half of the towel. Fold the towel in half and loosely roll it into a tube. Place the rolled towel upright in a jar loosely covered with plastic wrap or in an unsealed plastic bag, propped at an angle. This position keeps the towel moist and allows roots to grow downward and shoots to grow upward, making it easier to remove the seedlings. Towels should be kept in a warm place, preferably on top of a water heater or refrigerator at a temperature of 80 to 85°F. If a warmer place is unavailable, seeds will germinate at room temperature.

In 4 days, do the first germination check. Unroll the brown paper towel and remove and count the germinated seeds. After another 3 or 4 days, make a second count. If a large number of ungerminated seeds remain, continue the test another week as most non-dormant seeds should have germinated by then. At the end of the test, gently press each remaining seed. Dead or moldy seeds will be mushy under slight pressure. The remaining firm, plump seeds are likely dormant.

Calculate germination of the seed lot based on the number planted. If you planted 100 seeds, the number of seedlings that germinated and were removed equals the percent germination. If seeds were not counted initially, count the remaining seeds to calculate the percentage germination. You should always save a small amount of the seed you plant (¼ cup is plenty). If germination was poor, the saved seed can be used to recheck germination and determine if the problem is bad seed. If the seed won't germinate in a favorable environment such as the wet brown paper towel, don't expect success when the seed is planted in a field.

Figure 2. Switchgrass seed germinated on wetted blotter paper in a Petri dish (Robert Geneve, University of Kentucky).

Note: It is always a good idea to test the germination procedure by adding a few seeds of millet, alfalfa, or other small seed that you know will germinate with the switchgrass seeds. If these seeds germinate well, the germination test methods are working properly. If these seedlings are stunted, the brown paper towel may be too wet or rolled too tightly.

On-farm Prechill Method

Modified procedure from Wolf and Fiske

The prechill process involves soaking the seed in water for approximately 24 hours in water permeable bags, draining the excess water by drip-drying in a cool location for 8 to 12 hours, and chilling the seed in a refrigerator for several weeks. If the process is not properly conducted, you risk heat damage and premature germination during storage. Prechilled seed should be planted into a warm, moist seedbed; if the seedbed is dry, some of the seed may revert back into dormancy.

1. Place the seed in a water permeable bag (cloth or woven nylon) and store overnight in a refrigerator at approximately 40°F to chill before soaking.
2. Submerge the seed-filled bag in cold water (68°F or cooler) for 24 hours. Periodically check water temperature throughout the day. Ice can be added to water if temperature rises above 68°F.
3. Remove the bag from the water and allow it to drip dry in a cool location (68°F or cooler) for 8 to 12 hours.
4. Place the seed bag in large plastic garbage bag to prevent the seed from completely drying during chilling. Place the seed bag in a refrigerator or walk-in cold chamber and chill at approximately 40°F for 28 days. Periodically check refrigerator or walk-in chamber temperature to avoid freezing seed.
5. After 28 days, remove the seed bag from the refrigerator and empty the seed onto a dry tarp to dry. Evenly spread the seed over the tarp so that the seed is no higher than 3 inches in depth. Place a fan directed over the seeds to increase air flow and facilitate drying. Allow the seed to air dry for 3 days. Occasionally stir the seed to ensure even drying. Once properly dried, the seed should flow freely.
6. Store the prechilled, dried seed in a cool place (ideally 40°F and 40% relative humidity) before planting. Prechilled, dried seed should be planted as soon as possible, but if planting must be delayed, seed should be safe if properly stored.

Prechill Experiment

To verify the effectiveness of the prechill procedure described above, an experiment was conducted at the University of Kentucky under laboratory conditions. Switchgrass seed of four different varieties was treated using the recommended prechill procedure and other variations to compare. Laboratory germination tests were performed to determine the effectiveness of each method (see table footnotes for methods). Treatments tested were a dry control (no treatment), chill only (seed chilled for 42 days at 40°F), moistened only (seed soaked for 1 day at 68°F), and three treatments in which the seed was moistened (seed soaked for 1 day at 68°F) and then chilled for different lengths of time (14, 28, and 42 days at 40°F). Table 1 describes the germination results of the experiment.

According to the results, the recommended treatment of soaking the switchgrass seed for 24 hours and chilling the seed for 28 days resulted in improved germination 2 to 8 times greater than the

Table 1. Percent germination for various prechill treatment procedures for switchgrass varieties 14 d after planting

	Upland				Lowland	Average
Treatment	**Blackwell**	**Nebraska 28 (1)**	**Nebraska 28 (2)**	**Cave-In-Rock**	**Alamo**	
Dry control	8 (±1)[a]	41 (+4)	25 (±0)	19 (±6)	21 (±1)	23
Chill (42 d, 40°F)	12 (±7)	40 (±2)	31 (±2)	31 (--E3)	33 (±3)	29
Moistened (1 d, 68°F)	22 (±1)	45 (±16)	50 (±21)	50 (±21)	45 (--b=i)	42
Wet chill (1 d, 68°F; 14 d. 40°F)	51 (±14)	75 (±2)	85 (±4)	85 (±4)	54 (±7)	70
Wet chill (1 d. 68°F; 28 d. 40°F)	63 (±0)	83 (±2)	84 (±4)	84 (--E4)	66 (±5)	77
Wet chill (1 d. 68°F; 42 d. 40°F)	67 (±4)	65 (±2)	81 (±4)	81 (±4)	65 (±1)	72
Source: University of Kentucky Forage Laboratory Percent germination[b] = total number of germinated seeds/total number of seeds planted.						

[a] Average percent germination and standard deviation of experiment replicates (2).
[b] Germination test of 100 switchgrass seeds, 2 replicates incubated at 86°F for 14 days on wetted blotter paper using Petri dishes.

untreated seed. Over all switchgrass varieties tested, the recommended prechill treatment obtained some of the greatest increases in germination and had the highest average germination percentage.

Note that seed soaked for 24 hours and chilled for 14 days improved germination in all seed lots, and seed chilled for 42 days was not damaged. Therefore, a shorter or longer chilling period than the recommended 28 days can be used if time is an issue. Seed lot age is also an important factor to consider. In general, older seed lots will have a greater response to shorter chilling durations and are more prone to damage from longer chilling durations.

Storage of Prechilled, Dried Seed

Prechilled, dried switchgrass seed should be planted as soon as possible. If necessary, it is safe to store prechilled, dried seed when proper precautions are followed. Prechilled, dried seed must be stored in a cool place (ideally at 40°F and 40% relative humidity) to prevent unwanted germination. Prechilled, dried seed should not be allowed to fully dry, which could cause seed to revert back into dormancy. There is some concern that storing prechilled, dried seed for an extended period of time will cause seed death. To test seed longevity after chilling, the seed involved in the previously discussed study was stored at room temperature (~68°F) in the same bags used for the prechill procedure for a total of 168 days. Seeds were tested by the Seed Testing Laboratory at the University of Kentucky using recommended procedures to determine germination after 84 and 168 days of storage. Tables 2 and 3 describe the seed germination test results.

According to the test results, the germination of stored prechilled, dried seed at room temperature for 84 and 168 days after treatment varies depending on variety and seed lot. In general, germination percentage of the stored seed remained at similar levels or even increased. Blackwell

Table 2. Percent germination for prechilled, dried switchgrass seed after 84 days of storage 14 d after planting

	Upland				Lowland	
Treatment	**Blackwell**	**Nebraska 28 (1)**	**Nebraska 28 (2)**	**Cave-In-Rock**	**Alamo**	**Average**
Wet chill (1 d, 68°F; 14 d, 40°F)	87 (-±6)[a]	73 (±4)	89 (±4)	91 (±3)	68 (±6)	82
Wet chill (1 d, 68°F; 28 d, 40°F)	80 (±7)	77 (±3)	82 (±2)	94 (±1)	68 (±7)	80
Wet chill (1 d, 68°F; 42 d, 40°F)	82 (-±4)	76 (±4)	83 (±4)	88 (±7)	63 (±13)	78
Source: University of Kentucky Seed Testing Laboratory Percent germination[b] = total number of germinated seeds/total number of seeds planted.						

[a] Average percent germination and standard deviation of experiment replicates (4).
[b] Standard germination test of 50 switchgrass seeds, 4 replicates incubated at alternating temperatures of 68/86°F, KNO3 added, for 14 days on wetted blotter paper using Petri dishes.

Table 3. Percent germination for prechilled, dried switchgrass seed after 168 d of storage 14 d after planting

	Upland				Lowland	
Treatment	**Blackwell**	**Nebraska 28 (1)**	**Nebraska 28 (2)**	**Cave-In-Rock**	**Alamo**	**Average**
Wet chill (1 d, 68°F; 14 d, 40°F)	83 (±-3)[a]	73 (±5)	85 (-16)	93 (±4)	71(±4)	81
Wet chill (1 d, 68°F; 28 d, 40°F)	84 (±2)	71 (±3)	84 (±7)	91(±7)	62 (±10)	78
Wet chill (1 d, 68°F; 42 d, 40°F)	75 (±13)	64 (-=6)	75 (±8)	93 (±3)	57 (±9)	73
Source: University of Kentucky Seed Testing Laboratory Percent germination[b] = total number of germinated seeds/total number of seeds planted.						

[a] Average percent germination and standard deviation of experiment replicates (4).
[b] Standard germination test of 50 switchgrass seeds, 4 replicates incubated at alternating temperatures of 68/86°F, KNO3 added, for 14 days on wetted blotter paper using Petri dishes.

and Cave-In-Rock seed had increased germination for all three treatments after 84 and 168 days of storage. The Nebraska 28 seed lots and Alamo had mixed results with some treatments, having increased, decreased, or similar germination percentages after storage. However, when germination percentage decreased as a result of storage, germination percentages were still within acceptable levels. Ideally, only the amount of seed that is expected to be planted should be treated, but these results do show that the increased germination as a result of prechilling seed can be retained up to 6 months. If prechilled, dried seed is stored for longer than 6 months, if is recommended that the seed germination level be retested using a simple germination test or submitting the seed to the Seed Testing Laboratory at the University of Kentucky.

In conclusion, prechilling switchgrass seed is a suitable practice to break seed dormancy and increase germination levels, particularly when current germination percentages are 40 percent or lower. Ideally, only the amount of seed that is expected to be planted should be prechilled and planted as soon as possible into a warm, moist seedbed. Test results showed that, if necessary, prechilled switchgrass seed may be safely stored in a cool place (ideally at 40˚F and 40% relative humidity) for up to 6 months. After 6 months, the switchgrass seed should be retested to determine germination levels using a simple germination test or submitting the seed to the Seed Testing Laboratory, University of Kentucky College of Agriculture, Division of Regulatory Services, 103 Regulatory Services Building, Lexington, KY 40546-0275, (859) 257-2785, www.rs.uky.edu.

References

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