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# Mechanisms regulating seedling emergence of orchardgrass (*Dactylis glomerata* L.) and western wheatgrass (*Pascopyrum smithii* [Rydb.] L.): Dormancy change, seed fate and seeding date

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**Abstract**

Seed germination and seedling emergence of 'Arctic' and 'Lineta' orchardgrass (*Dactylis glomerata* L.) and 'Walsh' and 'LC9078a' western wheatgrass (*Pascopyrum smithii* [Rydb.] L.) were studied both in the field and laboratory. Four seeding dates were conducted each year over 2 years and seedling emergence and seed fate in the soil were monitored. The effects of alternating temperature and light on germination were quantified and correlated with seedling emergence from soil and in the field. Orchardgrass seeds were less dormant than western wheatgrass as indicated by the disparity in germination percentage between constant and alternating temperatures. Seed germination percentage was usually higher than seedling emergence in the field for orchardgrass but lower for western wheatgrass, and temperature was not responsible for the difference. Exposing orchardgrass seeds to light during germination check helped break dormancy in orchardgrass when temperature was unfavorable (low and/or constant temperatures), while favorable temperatures (optimal, alternating temperatures) conditions overcame the inhibiting effect of light in western wheatgrass. The final seedling emergence of orchardgrass was either similar among the four seeding dates or decreased slightly from early May to early June. For western wheatgrass, however, final seedling emergence increased with seeding dates from early to late May and decreased in early June. Soil temperatures of the first 2 weeks after seeding increased from the early May to late May and then decreased. These temperatures were below or near the optimal temperatures for western wheatgrass seeds to release dormancy and germinate. Germination of the previously buried seeds indicated that orchardgrass and western wheatgrass had the potential for a high germination percentage under field conditions for all seeding dates. While soil temperatures close to the optimal temperature for dormancy breaking and germination promoted germination of orchardgrass, the same conditions could cause deterioration of seeds if they failed to germinate. For western wheatgrass, deeper dormancy reduced seed mortality.


*Keywords:* Dormancy; Light; Orchardgrass (*Dactylis glomerata* L.); Seed burial; Seed germination; Seedling emergence; Temperature; Western wheatgrass (*Pascopyrum smithii* [Rydb.] L.)

## 1. Introduction

Orchardgrass (*Dactylis glomerata* L.) and western wheatgrass (*Pascopyrum smithii* (Rydb.) L.) are common forage species in western Canada. We have observed that the percentage of seedling emergence in the field is often different from the germination percentage tested before seeding. Therefore, using the pre-seeding germination percentage to determine seeding rate is not reliable for these species. Both species have seed dormancy and the dormancy can be released by alternating temperatures (Toole, 1976; Pannangpetch and Bean, 1984; Qiu et al., 2006). Seedling emergence of dormant seeds in the field is the combined result of dormancy release, seed germination, and seedling growth. Seedling emergence is affected by the interaction of weather conditions, soil, seed and seedling characteristics (Finch-Savage et al., 1998). Environmental variables such as soil temperature and soil moisture (Fyfield and Gregory, 1989; Finch-Savage and Phelps, 1993; Roman et al., 1999; Shrestha et al., 1999), soil penetration resistance (Vleeshouwers, 1997; Vleeshouwers and Kropff, 2000), tillage method (Oryokot et al., 1997; Roman et al., 2000), and burial depth (Redmann and Qi, 1992; Vleeshouwers, 1997; Qaderi et al., 2002) affect seedling emergence in the field. Among environmental factors in the field, soil temperature is most important in regulating seedling emergence when water is not limiting (Vleeshouwers and Kropff, 2000).

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Qiu et al. (2006) used thermal time models to quantify the effect of soil temperature on seed dormancy change and seedling emergence of two orchardgrass cultivars and concluded that thermal time accumulation under alternating temperature regimes accounted for most variance in seedling emergence of orchardgrass. The deep dormancy of western wheatgrass, however, resulted in low germination and a non-linear relationship between germination rate and temperature even under alternating temperature regimes, thus preventing the construction of thermal time models quantifying the effect of thermal time on seedling emergence of this species (Qiu, 2005). Differences between seed germination in Petri dishes and seedling emergence from soil were observed in both species, but the underlining physiological mechanisms remain unclear. Seedling emergence in the field is a complex process and the dynamics of seed population needs to be studied before a full understanding on the mechanism regulating seedling emergence is possible.

Objectives of this study were to determine the physiological mechanisms regulating seedling emergence of orchardgrass and western wheatgrass through the combination of laboratory experiments and field trials. It was hypothesized that: (1) requirements for dormancy breaking of the two species are fulfilled differently in the laboratory and the field, (2) seeding date and duration of seeds in the soil affect seed fate and thus seedling emergence.

## 2. Materials and methods

### 2.1. Seed sources

Certified seeds of two cultivars of orchardgrass, 'Arctic' and 'Lineta', and two cultivars of western wheatgrass, 'Walsh' and 'LC9078a', were used. Seeds were cleaned using a seed blower by controlling airflow at a fixed speed for 1.5 min. Light seeds blown into the upper container of the blower were discarded and heavy seeds left in the lower container were saved. The dry weight of the seeds averaged $0.91 \pm 0.06$ (mean $\pm$ S.E.) and $0.94 \pm 0.03$ mg seed$^{-1}$ for 'Arctic' and 'Lineta' orchardgrass, and $3.98 \pm 0.13$ and $3.54 \pm 0.21$ mg seed$^{-1}$ for 'LC9078a' and 'Walsh' western wheatgrass, respectively. Cleaned seeds were stored in darkness at $-18\,^{\circ}$C until use. Seeds were selected individually using tweezers to ensure that each seed was well formed, and then mixed with benomyl powder at a concentration of 0.05% (w/w) before experiments to prevent or reduce fungal infection.

### 2.2. Seed germination as affected by alternating temperature

Germination tests were conducted at 8 constant (between 0 and 35 °C with 5 °C increment) and 6 alternating temperature regimes (10 °C amplitude, 12/12 h). A randomized complete block design (RCBD) with five replicates was used and replicates were put into growth chambers (Sanyo Versatile Environment Chamber MLR-350H, Sanyo Scientific, USA) at 1-week interval. Designated temperatures were randomly allocated to each growth chamber. For each replicate, a unit of 50 seeds was imbibed on top of two layers of filter paper (Whatman No. 1) in 9 cm plastic Petri dishes. The filter paper was moistened with 5 mL distilled water and seeds were then carefully spread on top of the paper. Twenty Petri dishes (two species × two cultivars × five replicates) were randomized within each chamber in darkness. Clear plastic bags were used to seal Petri dishes to reduce water evaporation. Seeds were sprayed with 0.05% benomyl solution whenever there was a sign of microorganism contamination during germination tests. Germinated seeds were counted and removed at 24 h intervals; seeds with coleoptiles greater than 3 mm were considered germinated. Distilled water was added when necessary to keep the filter paper wet. Germination tests were terminated when no seeds germinated for 14 consecutive days. This experiment was also used to generate thermal time models for orchardgrass in a previous publication by the authors (Qiu et al., 2006).

### 2.3. Seedling emergence as affected by seeding date

Field trials were conducted at the field experimental station of Agriculture and Agri-Food Canada, Saskatoon Research Centre, Saskatoon, Canada. These trials were also used to validate thermal time models in a previous publication of the authors (Qiu et al., 2006). Seeding dates were 3 May, 15 May, 27 May, and 8 June 2003, and 7 May, 19 May, 31 May, and 10 June 2004. A RCBD with five replicates was used and the plot size was 1.0 m × 1.0 m. Sixteen treatments (two species × two cultivars × four seeding dates) were randomly allocated to plots in each block within a year. Within each plot, 200 seeds were hand-sown at a 1-cm depth in four rows. Irrigation (10 L per plot) was provided once a day to bring the top 2 cm of the soil to field capacity unless there was a precipitation event >5 mm in the previous 24 h and the soil was near its field capacity. Soil temperatures at the 1-cm sowing depth were recorded every hour using dataloggers (21X, Campbell Scientific Inc., Logan, Utah, USA). Seedling emergence in the field was monitored at 2-day intervals. Seedlings were counted as emerged when coleoptiles were visible from the soil surface and seedlings were removed after each counting. Weed seedlings were separated from orchardgrass and removed by hands regularly. The experiment was terminated after no new seedlings emerged for 14 consecutive days.

### 2.4. Seed fate as affected by seeding date

On each seeding date, four steel mesh containers (10 cm × 10 cm × 4 cm) were placed in each plot. The bottom of the container was 3 cm below the soil surface and the container was covered with 2 cm of soil. Filter paper bags containing 50 seeds of each cultivar were placed horizontally in each container and covered with 1 cm of soil. These bags were retrieved after 2, 4, 6, and 8 weeks of burial. Germinated seeds were recorded and then discarded. Non-germinated seeds were imbibed in Petri dishes at 15/25 °C in darkness as described above. Seed germination was counted daily and seeds with coleoptiles greater than 3 mm were considered germinated and removed. Water was added when necessary. Viability of non-germinated seeds at the end of the experiment was tested using the finger press-