Downy Brome Seed Bank Dynamics in Southwestern Saskatchewan

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Abstract

In order to study downy brome seed bank dynamics, a burial experiment was established near Maple Creek in August 1987. Downy brome seed was buried at four depths (2.5 to 20 cm), and placed on the soil surface, in nylon mesh bags. Seed was exhumed at monthly intervals in the fall of 1987 and throughout the 1988 growing season. Seed germination in the field in the fall of 1987 was greatest from the buried seed (almost 50%) while the surface seed exhibited little germination. This germination occurred in response to fall precipitation. Seed on the soil surface was not in contact with moist soil for a sufficient time to stimulate germination, so 80-90% of this seed had not germinated by freeze-up in 1987. However the surface collected seed had germination of 34% when transferred to an incubator in the laboratory, indicating environmentally induced dormancy in the field. There was little recruitment from the seed bank occurred in the spring of 1988 in spite of favorable moisture and temperature conditions. Seed on the soil surface remained viable until the 14th month but the buried seed at all depths had either germinated or deteriorated by the 9th month. This study was repeated in 1988, with similar results to date.

Introduction

Downy brome (<u>Bromus tectorum</u>) an aggressive, introduced annual grass, is now well established as a serious weed of winter wheat in southwestern Saskatchewan. Downy brome was likely introduced into Saskatchewan through contaminated winter wheat seed from the U.S. in the early 1960's. During the intervening period downy brome has spread throughout the southwest region to infest 90 townships across 28 rural municipalities in 1988.

Downy brome reproduces only by seed and survives from year to year as seed on the soil surface or buried in the soil (Evans and Young 1970). After ripening requirements have been reported for downy brome (Laude 1956; Thill et al.

1980), but this can be overcome quickly under field conditions so seed usually germinates readily after maturity. Caryopses of downy brome are large, lightweight, and elongated with a relatively long awn. These characteristics make intimate soil contact and burial difficult, so seed tends to remain on the surface of a bare seedbed (Evans and Young 1984). However downy brome can germinate without the base of the caryopsis in a moisture supplying substrate (Young et al. 1971).

In most downy brome infested areas the bulk of the germination occurs during the fall, if moisture is adequate (Wicks et al. 1971; Mack and Pike 1984; Hassan and West 1986) but many seeds in the soil do not germinate until the spring. Germination in the fall depends on appropriate microenvironmental conditions, particularly the presence of plant litter or trash cover which effectively moderates temperature and humidity fluctuations (Evans and Young 1970). In climates with moderate winter temperatures, downy brome may germinate all winter long (Mack and Pike 1983). Environmental conditions over the winter can lead to an acquired dormancy (Hull and Hansen 1974; Evans and Young 1975; Young and Evans 1975). The germination pattern shifts from one of simultaneous germination in the fall to continuous germination in the spring (Newman 1963). This may be an effective " strategy " for survival in unpredictable environments (Mack and Pike 1983).

Previous studies on downy brome seed bank dynamics have been restricted to the Intermountain regions of Washington Sate and the desert areas of Nevada (Evans and Young 1984; Mack and Pike 1983, 1984). Wicks et al. (1971) studied downy brome emergence and longevity in Nebraska. Recent evidence has shown that there is a wide variation in germination behavior of downy brome from different regions in the U.S. (Milby and Johnson 1987) but there are no comparable studies for Canadian populations (Upadhyaya et al. 1986).

The critical factors controlling downy brome populations are that (Young et al. 1969) :

1) large numbers of viable caryopses are carried over from one year to the next in litter and soil.
2) reductions in the density of downy brome populations can result in a net increase in caryopses production.
3) the simultaneous germination characteristics of freshly harvested downy brome seed can be environmentally conditioned to continuous germination.

Since downy brome is a recent ecological intruder in southwestern Saskatchewan, there is no information available on population dynamics in these climatic and soil zones. Control of downy brome would be simple if all the seed germinated each year, but the viable, ungerminated caryopses that remain on and in the soil are safe from our present weed control methods with the exception of long periods of fallow (Finnerty and Klingman 1962; Young et al. 1969; Evans et al. 1970).

These studies were conducted to provide important information on recruitment from the seed bank, mortality of seed, and seed longevity under the climatic conditions of southwestern Saskatchewan.

Materials and Methods

On August 15,1987 350 nylon mesh bags containing 100 downy brome seeds were buried near Maple Creek at 0, 2.5, 5.0, 10.0, and 20.0 cm from the soil surface. The experiment was conducted in a split-plot design with five replications. The experiment was repeated at the same site in 1988, but 200 seeds were placed in each bag. Seed used for the 1987 experiment for both the burial and as a "check" for the germination in the incubator were collected in 1987, while seed for the 1988 experiment was collected from the same site, but in 1988. Seed bags placed on the soil surface were covered with straw to simulate the microenvironmental conditions in a typical conservation tillage system. One seed bag from each plot was exhumed at monthly intervals from each experiment. Seed germination *in situ* was determined for the first three sampling dates. At later sampling dates, there was little germination in the field and it was difficult to determine the time of germination so these data were no longer collected after the April 1988 sample. The remaining intact seed in each bag was germinated in an incubator at 20/15 C and a 16 h photoperiod for 3 weeks.

Results and Discussion

During August of 1987 precipitation was well above normal for the burial area, so the seed was buried in moist soil (Table 1). Rainfall in the latter half of August (after the seed was buried) totaled 33 mm. This provided adequate soil moisture to stimulate germination of the seed. One month after burial (September 1987) mean germination of the buried seed in the field was 40% (Figure 1). In contrast, the surface seed averaged only 17% germination *in situ*. This difference in germination behavior can be at least partially attributed to environmental factors and the lack of "safe sites" on the soil surface. Soil at the burial site is very sandy, permitting rapid infiltration of any rainfall into the soil profile, with minumum persistence of water on the soil surface. Thus moisture levels on the soil surface were not high enough for a sufficient length of time to stimulate high germination levels. Although the September to November period was extremely dry in 1987 (only 29% of normal precipitation) seed germination in the field averaged 34% in the buried bags, but only 11% for the surface seed for the November sample. Moisture in the spring of 1988 stimulated germination in only a small number of seeds, irrespective of the depth of burial.

Results to date from the 1988 burial have shown a similar response of germination in the field to fall rains, with much greater germination in the buried seed than in the surface seed (Figure 1).

The proportion of intact, ungerminated seed in each bag was greater on the surface than in the buried bags, indicating that more of the buried seed had germinated or decomposed, compared to seed placed on the surface by the spring of 1988 (Figure 2). Seed which failed to germinate in the field in response to environmental conditions (i.e. intact seed) was germinated in an incubator for three weeks. Germination of the buried seed was less than 5% from collections in the fall of 1987 (Figure 3). The surface seed exhibited a gradual decline in germination from 34% at one month after burial to 1% after 15 months of burial. Some loss in seed viability was evident even after a short period of burial (one month) as the control seed (stored at 2 C) from the same seed source had 50 to 65% germination. Seed from the 1988 burial experiment had a similar decline in germination in the fall of 1988, but the germination percentages were somewhat greater (Figure 3).

Survival as seed in the soil is an important mechanism for continuing infestations of winter annual weeds under the climatic conditions of southwestern Saskatchewan (Budd et al. 1954). Downy brome seed longevity depends on the relative contributions of phenotype and environment to germination (Lonsdale 1988). Seed weight can affect dormancy characteristics, as can environmental effects on the parental plant during seed maturation.

In studies at Swift Current, downy brome seed buried three inches deep in soil that was periodically cultivated, had less than 2% emergence during the third year after burial (Chepil 1946). Buried seed germinated throughout the year, with peak germination in the spring, presumably in response to rainfall, but no environmental data were collected. In Nebraska, downy brome seed longevity ranged from 2 to 5 years across the state depending on the environmental conditions particular to each burial site (Wicks et al. 1971). More downy brome caryopses remained viable on the soil surface than at any other depths. Soil texture and precipitation were determining variables in the results of this study. Germination and emergence on the surface were greater in the fine textured soils (silt loam, silt clay loam) compared to the sandy loam. These differences occurred because of differing water infiltration rates among the soil textures. The surface of the sandy loam soil dried out rapidly compared to the finer textured soils.

Soil water potential ranging from -0.17 to -1.28 MPa had little effect on downy brome germination in a laboratory experiment (Thill et al. 1979) but McDonough (1975) reported that germinating seeds reach an equilibrium water potential at -1.7 MPa. Under field conditions soil texture influences soil structure and surface characteristics with respect to microtopography, water infiltration and retention, and heat capacity and temperature. Although most of the downy brome infestations in southwestern Saskatchewan occur on coarse textured soils, seed bank dynamics on finer textured soils in areas with higher precipitation (eg. adjacent to the Cypress Hills) may differ from the results reported here. In addition relatively small differences in precipitation amounts and distribution can result in large differences in recruitment from the seed bank, the survival of seedlings, and the induction of dormancy.

Several conclusions can be made regarding downy brome seed bank dynamics:

1) Downy brome germination occurs in response to rainfall/snow melt.
2) Peak germination of downy brome seed generally occurs in the fall if precipitation is adequate.
3) Spring germination occurs in seed with innate dormancy or after ripening requirements.
4) Seed survival is greatest on the soil surface.
5) Surface seed represents a source for continuing infestations for at least 15 months.
6) Buried seed had either germinated or lost viability after 7 months irrespective of the depth of burial.
7) Recruitment, mortality, and persistence of the seed bank vary from year to year with the weather conditions.
8) Safe sites for downy brome germination are more numerous in conservation tillage winter wheat production than in conventional tillage systems.

Table 1. Monthly precipitation (mm) at the seed burial site (Maple Creek North).

Month	1987	1988	Normal
January	--	13.4	27.7
February	--	23.9	22.0
March	--	17.2	17.0
April	--	trace	38.1
May	--	13.0	43.6
June	--	--	64.5
July	--	50.7	42.1
August	75.3	--	42.5
September	7.9	24.4	35.8
October	10.6	--	19.5
November	2.7	--	17.9
December	20.4	--	23.5

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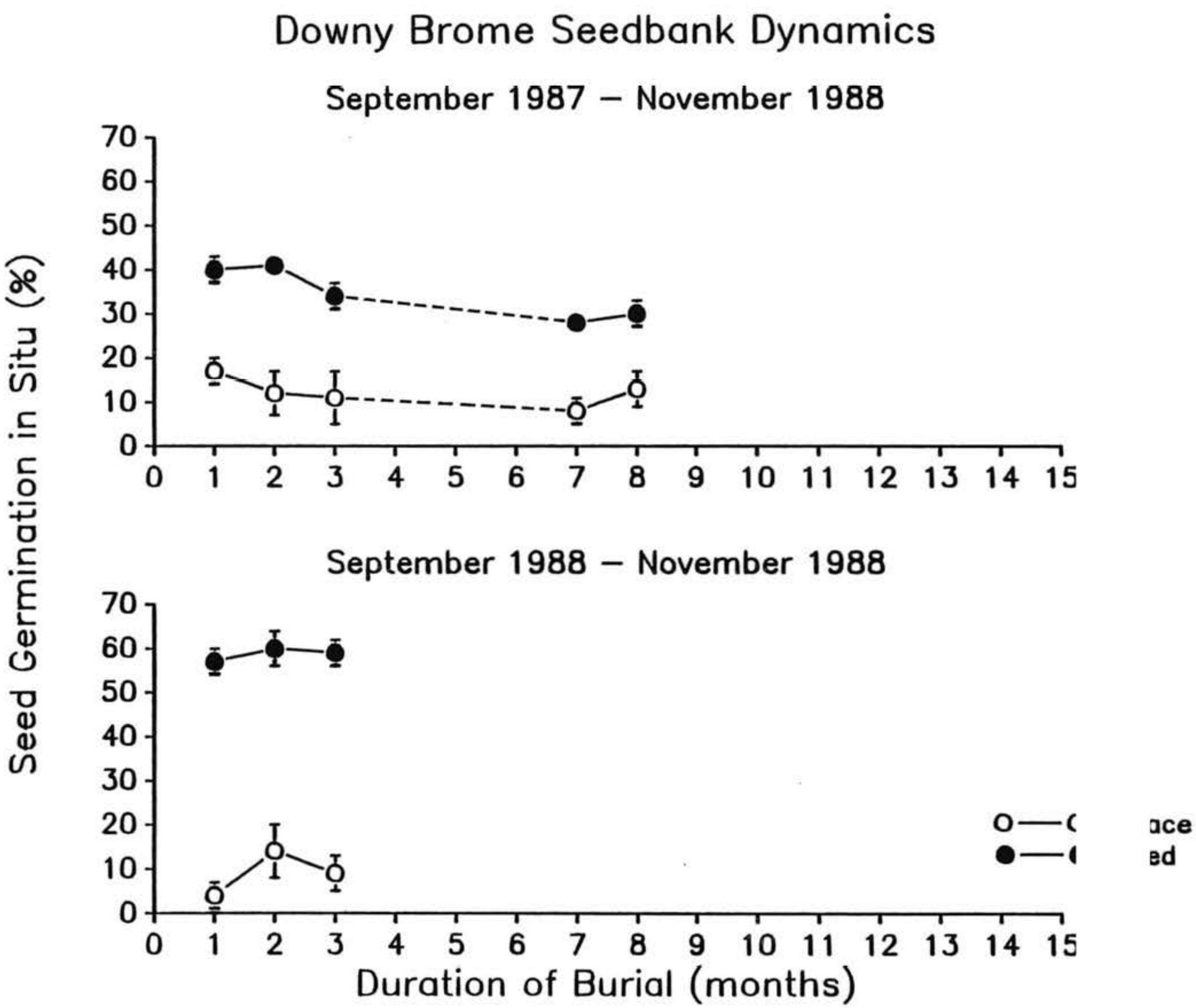

Figure 1. Recruitment from the seed bank in the field.

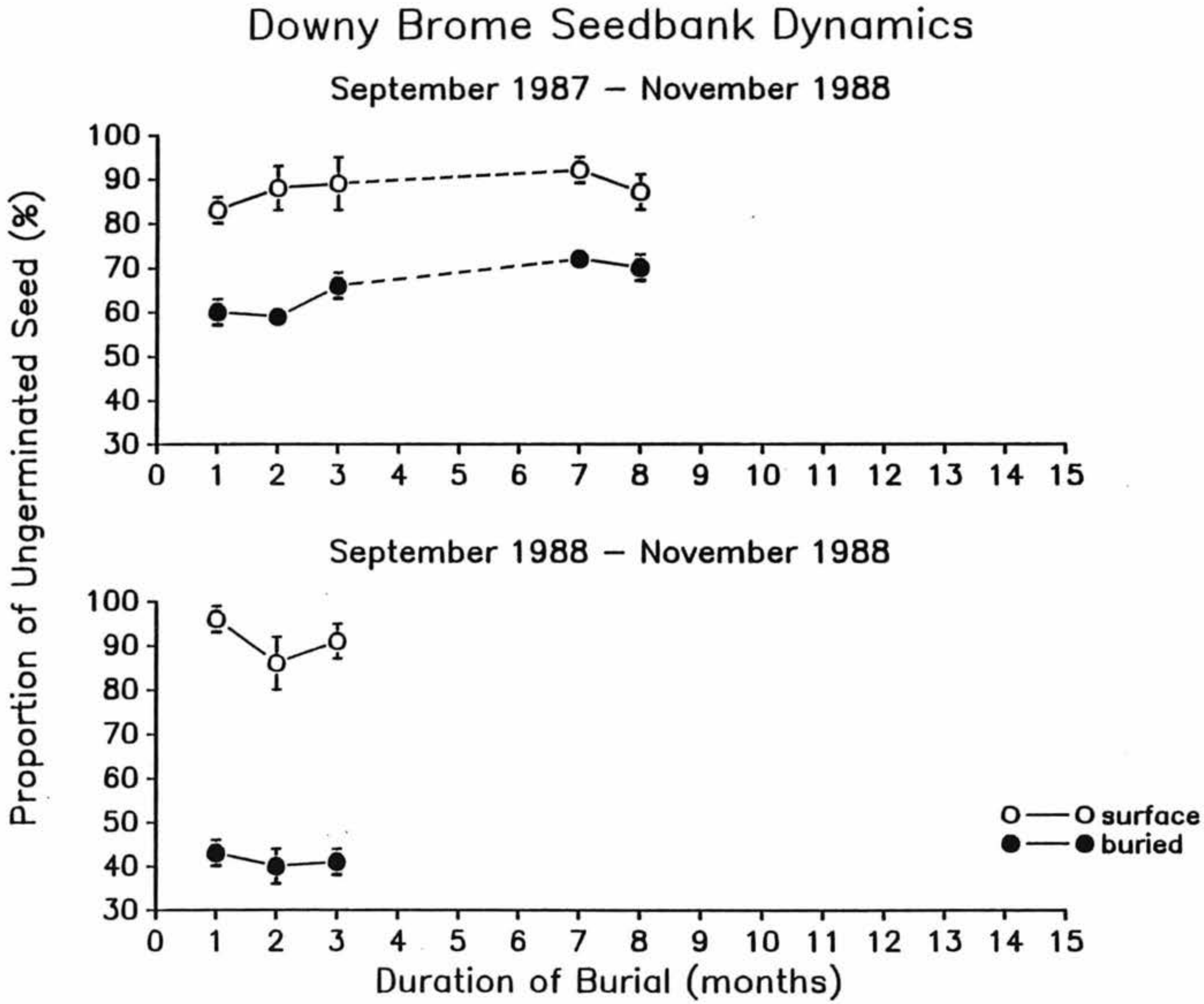

Figure 2. Proportion of intact, ungerminated seed recovered from the buried bags.

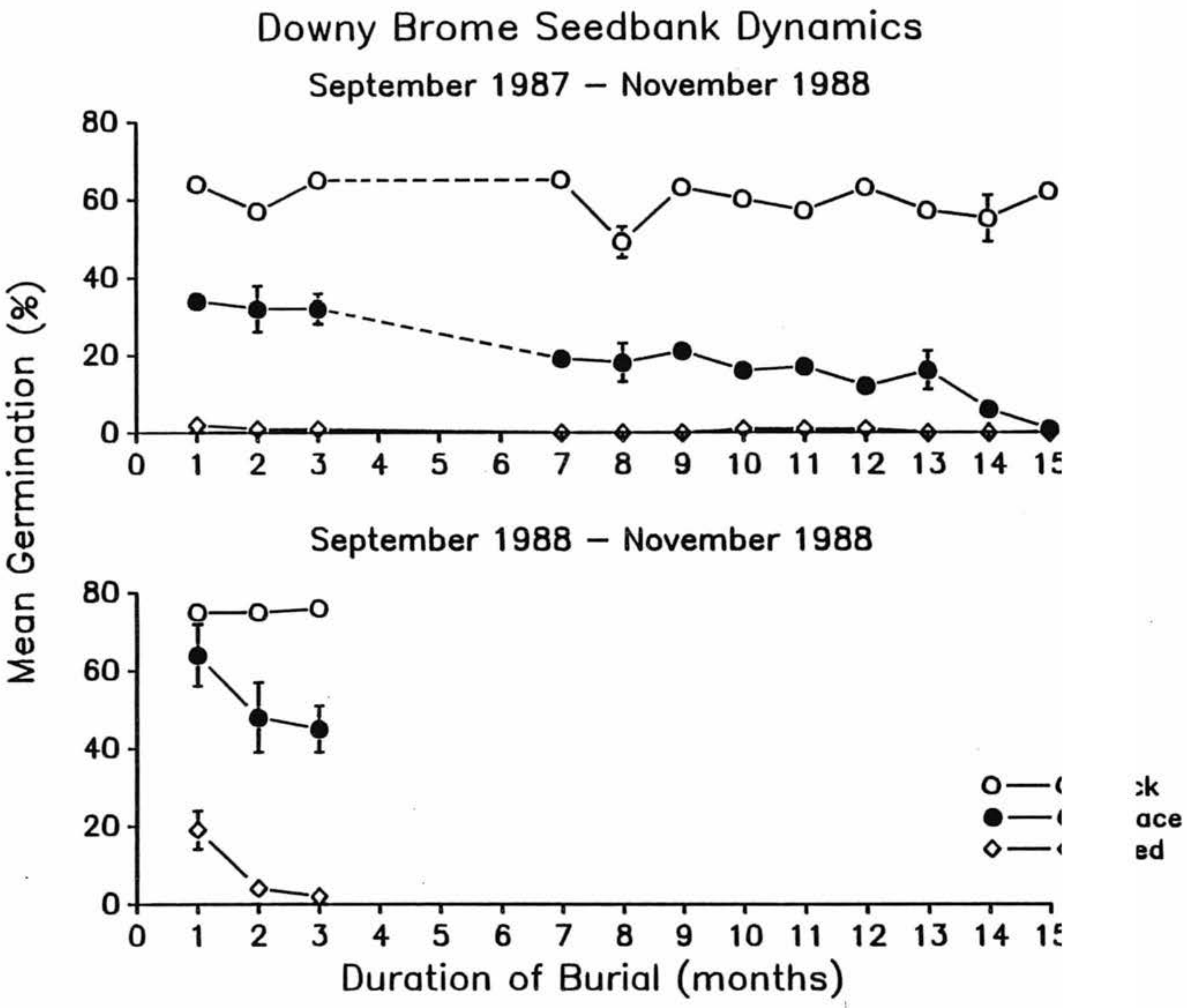

Figure 3. Germination of recovered, intact downy brome seed in ar   ıbator.