DISTRIBUTION, BIOLOGY, AND CONTROL OF DOWNY BROME (*Bromus tectorum* L.) IN SOUTHWESTERN SASKATCHEWAN

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Abstract

Downy brome was likely introduced near Maple Creek in 1960, and has since spread to infest parts of four Agricultural Extension Districts in southwestern Saskatchewan (Maple Creek, Leader, Swift Current, Shaunavon). By 1987, a total of 150 downy brome reports from 72 townships have been confirmed. During the first weed survey of annual crop fields infested with downy brome, 35 fields were visited and the kinds and numbers of weeds were identified according to standardized weed survey procedures. Downy brome density averaged 213 plants per square metre, and associated weeds were Japanese brome, flixweed, green foxtail, and wild buckwheat. Japanese brome was found in 5 fields, and was less abundant than downy brome in the area surveyed. Large numbers of downy brome seeds (50,000 seeds per square metre) were extracted from soil samples. Downy brome seeds buried in soil germinated more rapidly than those seeds on the soil surface. Most downy brome seeds (98%) buried 2.5, 5.0, 10.0, or 20.0 cm in soil germinated or deteriorated within 3 months. However, a few seeds remained viable in the soil after 3 months. Research is in progress to determine the relative winter hardiness of downy brome and winter wheat, and to develop chemical control methods.

Introduction

Downy brome, an aggressive, introduced winter-annual grass, has become established in southwestern Saskatchewan. It is especially troublesome in fall-seeded crops such as winter wheat and fall rye, but can also be found in pastures and waste areas.

Downy brome is known by a number of common names including cheatgrass, downy bromegrass, downy chess, and cheat (Fenster and Wicks 1979). In the northwestern U.S.A., several species of annual brome grasses commonly occur in winter wheat and are collectively referred to as the annual brome complex (Ratliff and Peeper 1987). In contrast, downy brome and Japanese brome are the only weedy annual brome species known to occur in Saskatchewan.

The apparent rapid spread of downy brome in North America has been attributed mainly to the change from spring to winter wheat production (Tisdale 1947), the adoption of conservation-tillage practices (Dao 1987), and the lack of effective chemical control methods (Wicks 1984). When stubble is maintained to catch snow and prevent winter kill of winter wheat, a favourable environment is created for establishment of downy brome (Dao 1987). If the current emphasis on reduced-tillage winter wheat production is to continue, reliable control methods for downy brome must be developed for southwestern Saskatchewan.

The objectives of this study are to determine: (1) the type and extent of the downy brome problem in southwestern Saskatchewan; (2) the density of downy brome in affected fields, associated weed flora, and size of viable seed bank; and (3) the germination pattern and longevity of buried downy brome seeds.

Materials and Methods

Distribution survey. In 1986, a Downy Brome Occurrence Questionnaire was mailed to producers in four Agricultural Extension Districts (Maple Creek, Leader, Shaunavon, Swift Current). The following questions were posed:

1. Does downy brome occur on any of the land you farm?
2. When did you first find downy brome in your fields?
3. Where does the weed occur on your farm?
4. What percentage of the quarter-sections you farm are affected?

A total of 259 questionnaires were completed and returned by August 1987. One hundred and fifty producers indicated that downy brome occurred on their farms. Seventy-six producers were not sure whether the weed was present, and 33 reported that downy brome did not occur on their farms.

Time-series distribution maps were constructed, using survey responses, to trace the spread of the weed over time. Responses to questions 3 and 4 were summarized in tabular form to describe the types of land and percentage of farmed quarter-sections affected by the weed in each district.

Weed survey of downy brome-infested fields. Two methods were used to locate fields infested with downy brome. Most locations were obtained from responses to the Downy Brome Occurrence Questionnaire mailed in 1986 to growers in southwestern Saskatchewan, but several locations were found with the assistance of Saskatchewan Agricultural Representatives and elevator agents. Posters with dried downy brome specimens were placed in elevators and other businesses frequented by growers. Growers reported locations of downy brome patches to cooperating Agricultural Representatives.

Only 35 fields were visited by the two surveyors because of time and financial constraints, and because many winter wheat fields had been harvested. The field survey was conducted during the first 2 weeks of July. Standard Saskatchewan field survey and analysis methods developed by Thomas (1985) were used, with the exception that only those areas of fields with high densities of downy brome were included. All of the surveyed fields are located in southwestern Saskatchewan. Half of the fields are within the rural municipality of Maple Creek, with the remainder in Piapot, Big Stick, Charmichael, Webb, and Riverside. The 35 fields surveyed consisted of winter wheat (24), fall rye (8), and spring cereals (3).

To estimate the size of the viable seed bank in the infested area of each surveyed field, soil samples were sieved to separate recognizable downy brome seeds from litter and soil. The recovered downy brome seeds were tested for viability in the lab. The remnant litter and soil of the samples were retained. These samples were incubated in the greenhouse in an attempt to germinate any seeds remaining undetected in the litter and soil.

Depth and duration of seed burial. On August 15, 1987, 350 nylon mesh bags containing 100 downy brome seeds were buried at Maple Creek at depths of 0, 2.5, 5.0, and 10.0 cm from the soil surface. The experiment was designed as a split-plot randomized complete block, with five replications. The main-plot factor was depth of burial, and sub-plot factor was duration of burial. Seed bags were exhumed in September, October, and November, 1987, and germination tests were conducted on all recovered seed. Seeds were placed in petri dishes containing 2 disks of filter paper and 5 ml of distilled water. Seeds were placed in an incubator operated at 20/5 C, with a 16/8 h light/dark photoperiod for 3 weeks.

Seeds which failed to germinate were examined under a microscope to determine whether seeds lacked embryos or endosperm. Seeds with intact embryos and endosperm were tested for viability with tetrazolium.

Results and Discussion

Distribution survey. Downy brome was likely introduced near Maple Creek in 1960 (Fig. 1). It has since spread to infest parts of four districts, with a marked increase in reports during the 1980's. By 1987, a total of 150 downy brome reports from 72 townships have been confirmed.

Marked differences in downy brome distribution are apparent between the extension districts (Table 1). Where the weed has been established the longest (Maple Creek), all types of land are affected (annual crop, perennial forage, seeded pasture, native pasture, not cropped). In contrast, where downy brome is currently spreading (Leader, Shaunavon, Swift Current), the weed is confined largely to annual crop land and land not cropped. Districts also vary in percentage of quarter-sections affected by downy brome on individual farms (Table 2). Some growers in Maple Creek and Leader report that nearly all quarter-sections they farm are affected. In contrast, growers in Shaunavon and Swift Current report that downy brome is present on less than 40 percent of the quarter-sections they farm.

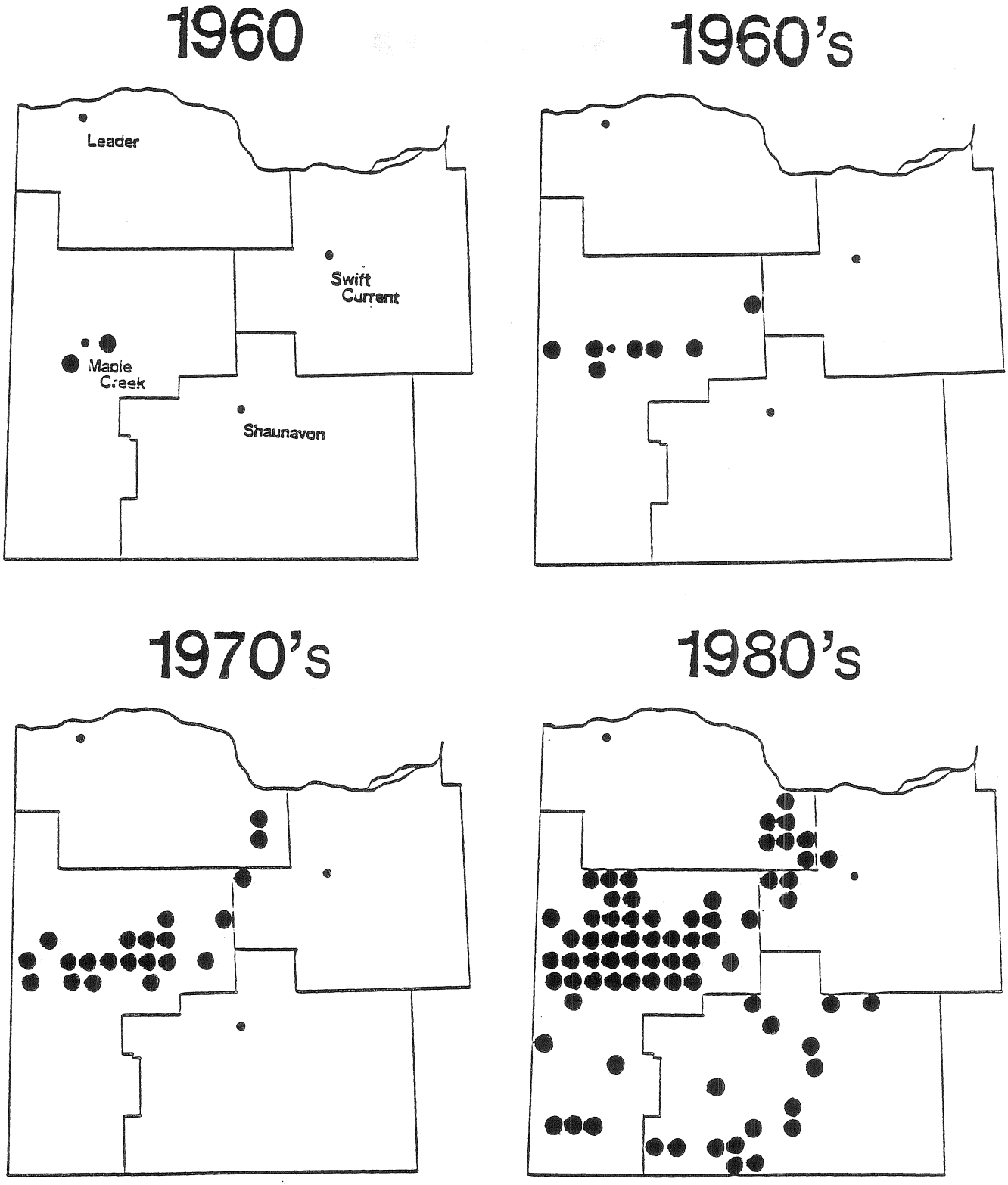

Fig. 1. Time-series distribution maps. Black dots represent townships where downy brome occurs, based on survey information.

Table 1. Types of land affected by downy brome.

Type of Land	District*			
	Maple Creek	Leader	Shaunavon	Swift Current
Annual crop	30	68	44	55
Perennial forage	19			
Seeded pasture	17		4	9
Native pasture	11			
Not cropped	23	32	52	36
No. of responses	243	25	27	11

*Expressed as a percentage of responses from each district. Note that some producers reported that more than one type of land was affected.

Table 2. Percentage of farmed quarter-sections affected by downy brome.

Percentage	District*			
	Maple Creek	Leader	Shaunavon	Swift Current
1 - 10	29	33	75	50
11 - 20	15	6	19	17
21 - 30	20		6	17
31 - 40	5	11		17
41 - 50	17	17		
51 - 60	2	5		
61 - 70	2			
71 - 80	3	17		
81 - 90	3	5		
91 - 100	3	5		
No. of responses	94	18	26	16

*Expressed as a percentage of responses from each district.

The differences in distribution of downy brome between districts may be explained, at least in part, by differences in time of initial introduction. For example, downy brome is more abundant in Maple Creek than Shaunavon, possibly because it was introduced approximately 20 years earlier in Maple Creek than Shaunavon. During this 20 year lag period, downy brome appears to have built a sizable population with export potential in Maple Creek. Alternatively, downy brome may not have spread as effectively in Shaunavon as in Maple Creek simply because environmental conditions may not have favoured its dispersal. However, it seems reasonable to expect downy brome to continue its rapid spread through southwestern Saskatchewan unless control programs are initiated specifically for this species.

Once downy brome was introduced near Maple Creek, it probably was distributed locally by farmers through movement of machinery, seed, or hay. Although downy brome was declared a noxious weed in Saskatchewan in 1987, there currently is no legislation in the Federal Seeds Act to limit the number of downy brome seeds in commercial crop or forage seed. Should this spread continue, downy brome may present a serious threat to winter wheat production in Saskatchewan.

Weed survey of downy brome-infested fields. The list of species found during the 1987 survey (Table 3) indicates that downy brome densities can be relatively high in winter cereals. The infested areas of surveyed fields averaged 213 plants per square metre. Downy brome is a serious competitor in winter wheat, and is particularly troublesome because of the lack of effective chemical control measures in this crop. In Oregon, downy brome densities of 108 and 538 plants per square metre have reportedly reduced winter wheat yields by 40 and 92%, respectively (Rydrych and Muzik 1968). In Idaho, winter wheat yields have been depressed 20 to 40% by downy brome populations of 55 to 110 plants per square metre (Massee and Higgins 1977). The similarity in growth habit to the crop and ability to reproduce before crop harvest enhance competitiveness and spread of downy brome.

Weed species associated with downy brome in these fields included Japanese brome, flixweed, green foxtail, and wild buckwheat. Other investigators have reported associations of downy brome in rangelands with Russian thistle, tumble mustard, and sunflower (Morrow and Stahlman 1984). Japanese brome was found in 5 of the 35 fields surveyed, and has been collected near Maple Creek, Shaunavon, and Swift Current. Survey results indicate that in some fields located in the foothills of the Cypress Hills, Japanese brome can be as troublesome as downy brome, since quadrats frequently contained in excess of 200 Japanese brome plants per square metre. As yet, Japanese brome is not as abundant as downy brome. In the northwestern U.S.A., downy brome is reported to become more abundant than Japanese brome as soil moisture supply decreases (Hulbert 1955). The favourable moisture conditions found in the foothills of the Cypress Hills may account for the apparent abundance of Japanese brome found in this localized area.

DOWNY BROME SURVEY

SPECIES	FREQUENCY (%)	FIELD UNIFORMITY (%)		FIELD DENSITY (#/M2)		DENSITY RANGE	RELATIVE ABUNDANCE
		ALL	OCCURRENCE	ALL	OCCURRENCE	LOW---HIGH	
DOWNY BROME	100.0	97.7	97.7	213.8	213.8	18.4 - 805.2	182.2
JAPANESE BROME	14.3	8.0	56.0	21.1	147.8	0.4 - 489.2	18.3
FLIXWEED	40.0	7.1	17.9	1.0	2.4	0.2 - 10.0	18.0
GREEN FOXTAIL	14.3	6.4	45.0	5.5	38.4	0.6 - 144.0	11.1
WILD BUCKWHEAT	20.0	5.0	25.0	0.6	2.9	0.2 - 9.0	10.0
ROSE SPECIES	17.1	2.9	16.7	0.5	2.9	0.4 - 5.0	7.6
KOCHIA	5.7	3.6	62.5	6.5	113.9	7.4 - 220.4	6.8
RUSSIAN THISTLE	11.4	3.1	27.5	0.4	3.3	0.2 - 10.2	5.9
LAMB'S-QUARTERS	14.3	1.3	9.0	< 0.1	0.7	0.2 - 2.2	5.5
FOXTAIL BARLEY	8.6	1.9	21.7	0.4	4.6	0.2 - 10.0	4.2
STINKWEED	8.6	1.9	21.7	0.1	1.5	0.6 - 2.2	4.0
PYGMYFLOWER	5.7	1.6	27.5	1.2	21.4	0.6 - 42.2	3.4
SKELETONWEED	5.7	1.9	32.5	0.2	3.4	2.2 - 4.6	3.2
WILD OATS	5.7	1.7	30.0	0.4	6.7	6.4 - 7.0	3.1
CANADA BLUEGRASS	5.7	0.7	12.5	< 0.1	1.0	0.6 - 1.4	2.3
FIELD HORSETAIL	2.9	1.4	50.0	0.2	6.8	6.8 - 6.8	1.9
PRAIRIE SUNFLOWER	2.9	1.0	35.0	0.1	3.8	3.8 - 3.8	1.6
QUACK GRASS	2.9	0.7	25.0	0.1	4.8	4.8 - 4.8	1.4
COMMON PEPPER-GRASS	2.9	0.3	10.0	< 0.1	0.8	0.8 - 0.8	1.1
PRICKLY LETTUCE	2.9	0.3	10.0	< 0.1	0.4	0.4 - 0.4	1.1
ALFALFA	2.9	0.3	10.0	< 0.1	0.4	0.4 - 0.4	1.1
THYME-LEAVED SPURGE	2.9	0.1	5.0	< 0.1	0.4	0.4 - 0.4	1.0
BLUEBUR	2.9	0.1	5.0	< 0.1	0.2	0.2 - 0.2	1.0
SMALL-SEEDED FALSE FLAX	2.9	0.1	5.0	< 0.1	0.2	0.2 - 0.2	1.0
REDROOT PIGWEED	2.9	0.1	5.0	< 0.1	0.2	0.2 - 0.2	1.0
CANADA FLEABANE	2.9	0.1	5.0	< 0.1	0.2	0.2 - 0.2	1.0
ANNUAL SMARTWEED SPECIES	2.9	0.1	5.0	< 0.1	0.2	0.2 - 0.2	1.0

Table 3. List of species found in 1987 weed survey of annual crop fields infested with downy brome.

The size of the viable seed bank in the downy brome-infested area of each surveyed field appears to be relatively large. An average of 50,000 recognizable downy brome seeds per square metre (10 cm depth) were extracted from soil samples. Nearly all recognizable seeds germinated when tested for viablility in the lab.

Following 8 weeks of greenhouse incubation of remnant litter and soil, an average of 17,000 seedlings per square metre emerged. These results demonstrate that many viable seeds remained in the soil samples after sieving. Minute seeds and fractured remnants of viable downy brome seeds are difficult to recognize, when they lose their lemmas and paleas after overwintering in the field.

Depth and duration of seed burial. Downy brome survives from one year to the next as viable seeds in litter on the soil surface, or buried in the soil (Young, Evans and Eckert 1969). However, the reported longevity of seeds varies widely, possibly due to differences in climate, soil texture, or depth of burial. Some investigators have reported that downy brome seeds germinate in the fall or spring, and that practically all of the seeds germinate as soon as conditions are favourable (Hulbert 1955; Klemmedson and Smith 1964; Thill 1979). However, other workers have shown that viable downy brome seeds persist in the litter and soil for more than one season (Bund, Chepil and Doughty 1954; Chepil 1946; Young, Evans and Eckert 1969). In Nebraska, some viable seeds were reported after five years of burial (Wicks, Burnside and Fenster, 1971). Thus, as an initial step in developing a control program, information is needed on the longevity of downy brome seeds under Saskatchewan conditions.

Most downy brome seeds (98%) buried 2.5, 5.0, 10.0, or 20.0 cm in soil at Maple Creek germinated or deteriorated in the field by November 15, 1987. Microscopic examination of seeds which failed to germinate in the field or lab revealed that nearly all seeds lacked embryos and endosperm. Downy brome seeds may, therefore, not have a long period of enforced dormancy. However, a few buried seeds remained viable (Table 4), and may represent a source for re-infestation.

Table 4. Viability (% germination) of seeds exhumed from five depths after a three week incubation period.

Burial depth from soil surface (cm)	Percent Germination		
	Date exhumed		
	Sept. 15	Oct. 15	Nov. 15
0	31.0	29.8	25.6
2.5	1.0	0.2	0.0
5.0	1.0	0.8	0.6
10.0	0.2	0.8	0.6
20.0	2.6	2.2	1.4

More downy brome seeds remained viable when placed at the soil surface (25.6%) than at any other depth (Table 4). Seeds at the soil surface are not often in contact with moist soil for sufficient periods of time to allow germination. Most of the downy brome seeds produced in reduced-tillage winter wheat systems remain at or near the soil surface, and these seeds likely represent the main source for re-infestation. Additional seeds will be exhumed in 1988 to determine whether any downy brome seeds survive from one year to the next, and whether spring germination is likely to occur in Saskatchewan.

Future Work. An experiment is in progress to compare the level of cold hardiness of downy brome with that of winter wheat. The purpose of the experiment is to determine whether downy brome is likely to survive the harsh winter conditions which occur north of currently infested areas. Seedlings of downy brome and winter wheat collected in November 1987 from 12 fields near Maple Creek are being freeze tested at the University of Saskatchewan to determine their levels of cold hardiness.

Two field experiments were established in September 1987 at Maple Creek to demonstrate chemical control methods. In one experiment, control of downy brome will be evaluated following application of nonselective herbicides (paraquat + 2,4-D or glyphosate + 2,4-D) at 4 different growth stages of the weed. In addition, control of downy brome and tolerance of winter wheat will be evaluated following fall 1987 and spring 1988 applications of unregistered selective herbicides (cinmethylin, napropamide, metribuzin, and ethyl-metribuzin).

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