Weed Science. 1987. Volume 35:149–154

# Persistence, Germinability, and Distribution of Jointed Goatgrass (*Aegilops cylindrica*) Seed in Soil[1]

WILLIAM W. DONALD and ROBERT L. ZIMDAHL[2]

*Abstract.* The persistence and germinability of jointed goatgrass (*Aegilops cylindrica* Host. #[3] AEGCY) seed (caryopses) were studied over a five-year period between 1979 and 1984 at five locations in Colorado, Kansas, and Nebraska. Seed were buried in open-mesh packets and the sites were not disturbed for the duration of the study. Seed survival at burial depths of 5, 15, or 30 cm decreased rapidly over the first three years at all locations. By the third year, less than 7.4 ± 6.5% (mean ± SD) of the seed remained at 5 cm in the soil at all locations. By the third, fourth, and fifth year there was total loss of seed at one, two, and four sites at the 5-cm burial depth. Only three of five sites had total loss of seed at 30 cm after five years. The proportion of surviving seed that were germinable increased with time and was almost 100% after three years of burial. Because jointed goatgrass seed were relatively transient in the soil profile, fallowing of infested areas for a three-year period may significantly reduce populations of this weed or eradicate it, depending upon location.

*Additional index words.* Dormancy, *Triticum aestivum*, AEGCY.

## INTRODUCTION

Jointed goatgrass is a problem weed in the winter wheat (*Triticum aestivum* L.)-fallow rotation of the Central Great Plains (8, 12, 14). Because this weed is genetically related to wheat, attempts to selectively control it with herbicides in winter wheat have failed (7). Herbicides that control volunteer winter wheat in chemical fallow also control jointed goatgrass (9, 10, 11, 14). A better understanding of seed biology may suggest ways to manage it in the winter wheat-fallow rotation. The goal of this research was to characterize the spikelet distribution and caryopsis persistence of jointed goatgrass in soils in the Central Great Plains. The term "seed" will be used in place of caryopsis hereafter.

## MATERIALS AND METHODS

**Spikelet distribution.** Nine intact soil cores (10-cm-diam) were taken in early May 1979 with a golf-course cup digger to a depth of 32.5 cm at two locations near Genoa and Limon, CO (Figure 1). The sites were farms in which primary tillage was by discing. Each core had a surface area of 78.5 $cm^2$, for a total of 706.5 $cm^2$ per nine cores. Cores were divided into five segments (soil surface, 0.1 to 3.5 cm, 3.5 to 8.8 cm, 8.8 to 16.3 cm, and 16.3 to 32.5 cm). Jointed goatgrass spikelets were washed free of soil and counted, and the data were expressed as spikelet number per $m^2$.

In separate studies at the Genoa location, soil cores were taken along a transect at 0, 1.5, 3.0, 4.6, 6.1, 7.6, 9.1, 12.2, and 15.2 m from the field border into a wheat field infested with jointed goatgrass. At each distance, three cores (10-cm-diam) were combined and the number of spikelets was determined on the soil surface and in the soil to a 16.3-cm depth. The number of seed was not determined in either study.

**Seed persistence in soil.** Jointed goatgrass spikelets were gathered from a grain bin near Genoa, CO, in January 1978. Wheat and jointed goatgrass seed in the bin had been harvested in early August 1977. Newly formed, mature spikelets were gathered from a farmer's wheat field near Limon, CO, in early August 1979. Seed persistence studies were initiated between August 27 and 29, 1979, at Rocky Ford and Fort Collins, CO, and Tribune, KS, and on September 29, 1979, at Akron, CO, and Sidney, NE (Figure 1). Soil characteristics for each site are summarized in Table 1. A randomized complete block design with four blocks was used at each location. Spikelets from the Genoa and Limon sites were buried at random 5, 15, and 30 cm below the soil surface within each block. Since there were insufficient seed for both seed sources to be planted at all locations, only the Limon source was buried at Tribune, KS. A golf-course cup digger was used to excavate holes (10-cm-diam). One hundred spikelets of jointed goatgrass were placed in closed fiberglass mesh packets (5 by 7.5 cm) made of window screen (5.5 wires per linear cm)[4] which were buried at each depth in one hole and joined with nylon fishing line to help relocate them. There were 190 ± 4 (mean ± SD) and 183 ± 3 seed per 100 spikelets for the Genoa and Limon seed sources, respectively. The seed packets were covered with an undisturbed core of soil as they were stacked at three different depths in each hole. Enough packets were buried so that separate packets could be sampled over a five-year period. The site was not tilled over this period.

Seed packets were unearthed in the last week of August or the first week of September from 1980 to 1984. Packets were air dried and standard germination assays were conducted. Seed were placed on germination paper in darkness at 20 C and 100% relative humidity for three weeks. The numbers of intact spikelets, seed in the spikelets, and germinated seed were counted. For most locations and depths, the spikelets (hull) covering the seed decayed with the seed, but at some locations in the fourth and fifth year, the hull decayed before the seed. Consequently, the total number of surviving seed and the number that germinated are expressed as a percentage of the initial number of buried seed,

[1] Received for publication April 10, 1986, and in revised form August 29, 1986.

[2] Res. Agron., Agric. Res. Serv., U.S. Dep. Agric., Metabolism and Radiation Res. Lab., Fargo, ND 58105 and Prof., Dep. Plant Pathol. and Weed Sci., Colorado State Univ., Fort Collins, CO 80523.

[3] Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

[4] 14-mesh screen.

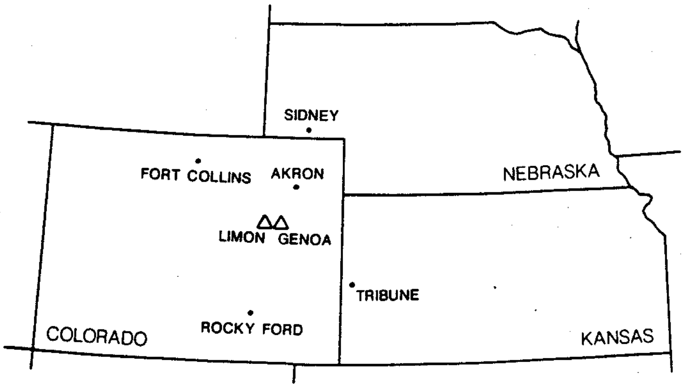


*Figure 1.* The geographic location of the jointed goatgrass seed sources (Δ) and burial sites for studies of seed persistence (●).

rather than as a percentage of the number of spikelets. Four lots of 100 spikelets were used for germination tests.

Analysis of variance (ANOVA) and regression analysis of all data for all years were not possible because the ANOVA assumption of uniform variance did not apply (20, 31). In fact, variance decreased sharply during the last three years of the study. Data transformation did not improve homogeneity of variance. For this reason, only means and standard deviations are presented. Mean separation procedures, such as Duncan's multiple range test or the least significant difference, were not used because the data violated the assumptions of ANOVA, and mean separation tests can be used only after the ANOVA is demonstrated to be significant (31).

## RESULTS AND DISCUSSION

**Spikelet distribution.** Sites near Limon and Genoa, CO, had been in a continuous winter wheat-fallow rotation for the previous eight years before sampling in 1979. Disking was the major form of primary tillage. The two sites had significantly different numbers of spikelets per $m^2$ averaged over all depths (P = 0.0214). The number of recovered spikelets decreased as soil depth increased, averaged over two locations (P = 0.0001) (Table 2). Because the interaction between location and depth was nonsignificant (P = 0.1317), the results could be presented as the average for the two locations.

There were 2720 jointed goatgrass spikelets per $m^2$ to a depth of 32.5 cm averaged over the two locations (Table 2). There were 1730 and 3720 spikelets per $m^2$ for Limon and Genoa, respectively. One spikelet recovered per 706.5 $cm^2$ equaled at least 14 spikelets per $m^2$. Since each spikelet usually has one or two seed (Table 3), spikelet number may underestimate seed number per $m^2$, but not by more than half. Densities of 12 635 seed per $m^2$ of poverty brome (*Bromus sterilis* L. # BROST) were found in cereals in England (15) and 50 000 seed per $m^2$ of slender foxtail (*Alopecurus myosuroides* Huds. # ALOMY) were found in winter cereals (25). The number of seed in soil can increase rapidly under certain circumstances. For example, Edwards (13) observed 200, 4980, and 14 290 seed per $m^2$ of wild mustard (*Sinapis arvensis* L. # SINAR) over three succeeding years in wheat.

Eighty-nine percent of the seed was on the surface or buried in the top 3.5 cm (Table 2). The remainder were buried between 3.5 and 16.3 cm and none were found below 16.3 cm. Because disking was the method of primary tillage, this distribution supports observations that shallow tillage leaves weed seed close to the soil surface (28).

The spatial variability of spikelets was studied by taking samples along a 15-m transect extending into a heavily infested field from the border (Figure 2). Jointed goatgrass often encroaches into fields from the borders where seed are initially spread by custom combines. It was appropriate to sample the border because this weed was not randomly distributed in the wheat field. There was a five- to tenfold difference in mean spikelet density, with the greatest density occurring at 1.5 m from the field border. At the highest densities, the greatest proportion of jointed goatgrass spikelets was found on the soil surface. There were no seed on the surface beyond 4.5 m from the border of the field. Mean

*Table 1.* Field soil characteristics at the five experimental sites selected for jointed goatgrass seed burial studies.

| Location | Soil texture | Sand | Silt | Clay | Organic matter |
|---|---|---|---|---|---|
| | | (%) | | | |
| Akron, CO[a] | Silt loam | 37 | 46 | 17 | 0.8 |
| Fort Collins, CO[b] | Clay loam | 46 | 35 | 19 | 1.8 |
| Rocky Ford, CO[c] | Silty clay loam | 41 | 37 | 22 | 1.2 |
| Sidney, NE[d] | Silt loam | 29 | 54 | 17 | 1.6 |
| Tribune, KS[e] | Silt loam | 17 | 62 | 21 | 1.3 |

[a]Weld silt loam, fine montmorillonitic, mesic Aridic Paleustolls.

[b]Nunn clay loam, fine montmorillonitic, mesic Aridic Argiustoll.

[c]Rocky Ford silty clay loam, Ustic Torriorthents; fine-silty, mixed (calcareous), mesic.

[d]Alliance silt loam, fine-silty, mixed, mesic Aridic Argiustoll.

[e]Ulysses silt loam, fine-silty, mixed, mesic Aridic Argiustoll.

*Table 2.* The distribution of jointed goatgrass spikelets in the soil profile averaged across two locations, Genoa and Limon, CO, in 1979.

| Depth of recovery | Spikelet distribution[a] | |
|---|---|---|
| (cm) | (spikelets per $m^2$) | (% of total) |
| Surface | 1370 a | 50.2 |
| 0.1 – 3.5 | 1060 a | 39.1 |
| 3.5 – 8.8 | 250 b | 9.2 |
| 8.8 – 16.3 | 40 b | 1.5 |
| 16.3 – 32.5 | 0 | 0 |
| Total | 2720 | 100 |

[a]Means followed by the same letter are not statistically different at P = 0.05 by Duncan's multiple range test.

*Table 3.* The percentage of jointed goatgrass spikelets containing one, two, or three seed.

| Seed source | Percentage of total spikelets containing seed[a] 1 seed per spikelet | 2 seed per spikelet | 3 seed per spikelet |
|---|---|---|---|
| | (%) | | |
| Genoa, CO | 20.4 ± 6.3 | 79.0 ± 6.3 | 0.6 ± 1.0 |
| Limon, CO | 24.2 ± 4.8 | 75.8 ± 4.8 | 0 |

[a]Means ± standard deviation are presented.

spikelet densities to a depth of 16.3 cm ranged from 1.2 to 23.5 million spikelets per ha.

**Seed persistence in soil.** Spikelets used in this study had one or two seed (Table 3), and there was therefore variability in the number of seed buried. Consequently, surviving seed and germination percentages are expressed as a proportion of the mean number of seed per 100 spikelets initially present. Germination was not expressed as a percentage of the seed surviving each year because so few seed persisted after three years. Spikelets rather than excised seed were buried because the spikelet is the natural dispersal unit of jointed goatgrass (8, 17, 24). The spikelet is shed when the rachis of the spike disarticulates either between the spikelets or at the base of the spike (24).

Studies of seed persistence that measure only seed viability or germinability can seriously underestimate total seed numbers. In this study, the number of seed present was used to estimate seed survival, irrespective of viability. Germinability was used to estimate viability because the standard tetrazolium chloride test was unreliable.

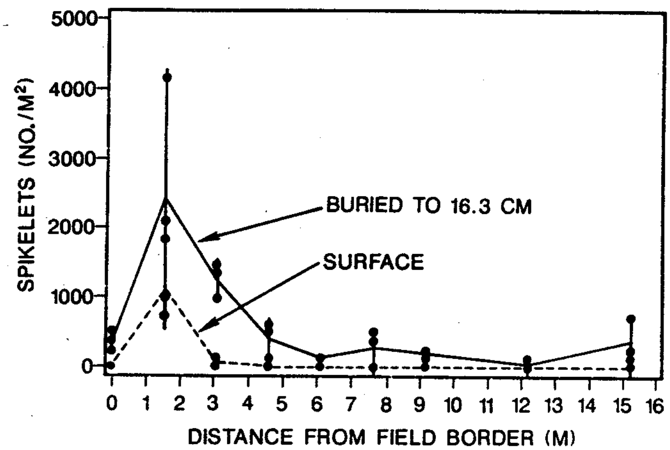


*Figure 2.* The relationship between jointed goatgrass spikelet density and distance from the field border near Genoa, CO. The data points (•) and vertical standard deviation bars are presented. The means at different distances from the border are joined by a solid line.

The number of jointed goatgrass seed of the Limon seed source remaining in soil decreased rapidly over the first three years of the experiment at five locations (Table 4). Less than 9.4 ± 6.2% (mean ± SD) of the seed remained in soil by the third year at three depths and all burial sites, except Tribune. After four years, less than 0.7 ± 0.8% of the seed remained at the 5-cm depth at the same four of five locations. Total loss of seed buried at 5 and 15 cm occurred after five years at all locations, and at two of five locations when buried at 30 cm. Limon seed persisted five years at 30 cm at Akron, CO, Tribune, KS, and Sidney, NE. Thus, there was rapid elimination of the soil seed reserve in three to five years without soil disturbance, especially after shallow burial at 5 cm. Shallowly buried seed are usually least persistent (28).

*Table 4.* The percentage of jointed goatgrass of the Limon seed source remaining as influenced by location, depth of burial, and year after burial. At the start, 100.0 ± 1.6% of the seed were present.

| Year | Depth of burial | Fort Collins | Rocky Ford | Akron | Sidney | Tribune |
|---|---|---|---|---|---|---|
| | (cm) | (%)[a] | | | | |
| 1 | 5 | 90.6 ± 2.0 | 89.0 ± 2.4 | 90.4 ± 2.2 | 89.0 ± 1.2 | 85.6 ± 6.0 |
| 2 | | 29.7 ± 13.8 | 3.0 ± 1.5 | 44.3 ± 2.2 | 42.9 ± 3.6 | 28.1 ± 2.5 |
| 3 | | 0 | 0 | 2.2 ± 1.9 | 1.3 ± 1.4 | 0.2 ± 0.5 |
| 4 | | 0.2 ± 0.5 | 0.1 ± 0.2 | 0.7 ± 0.8 | 0.5 ± 0.9 | 2.1 ± 1.1 |
| 5 | | 0 | 0 | 0 | 0 | 0 |
| 1 | 15 | 89.7 ± 1.7 | 90.6 ± 0.9 | 65.5 ± 38.4 | 80.4 ± 23.2 | 89.7 ± 2.0 |
| 2 | | 5.0 ± 10.0 | 0 | 33.2 ± 13.0 | 45.1 ± 1.1 | 30.1 ± 5.8 |
| 3 | | 0.3 ± 0.7 | 0 | 9.4 ± 6.2 | 6.7 ± 4.7 | 16.6 ± 8.0 |
| 4 | | 0 | 0.2 ± 0.5 | 0.5 ± 0.5 | 1.9 ± 2.0 | 3.3 ± 3.0 |
| 5 | | 0 | 0 | 0 | 0 | 0 |
| 1 | 30 | 63.5 ± 36.8 | 87.9 ± 4.1 | 98.3 ± 9.9 | 90.2 ± 0.9 | 89.7 ± 3.0 |
| 2 | | 3.1 ± 5.9 | 1.6 ± 1.9 | 34.0 ± 13.8 | 42.4 ± 5.2 | 37.2 ± 1.7 |
| 3 | | 0.2 ± 0.5 | 0 | 4.7 ± 3.3 | 7.4 ± 6.5 | 27.4 ± 4.3 |
| 4 | | 0 | 0.7 ± 1.4 | 2.1 ± 0.8 | 3.8 ± 2.9 | 5.9 ± 9.8 |
| 5 | | 0 | 0 | 0.2 ± 0.5 | 0.2 ± 0.5 | 12.4 ± 9.3 |

[a]Means ± standard deviations are presented.

*Table 5*. The percentage of jointed goatgrass of the Genoa seed source remaining as influenced by location, depth of burial, and year after burial. At the start, 100.0 ± 2.8% of the seed were present.

| Year | Depth of burial | Fort Collins | Rocky Ford | Akron | Sidney |
|---|---|---|---|---|---|
| | (cm) | (%)[a] | | | |
| 1 | 5 | 85.4 ± 4.5 | 87.8 ± 2.3 | 86.9 ± 2.3 | 83.7 ± 7.1 |
| 2 | | 30.6 ± 15.4 | 11.2 ± 3.0 | 43.8 ± 0.2 | 39.2 ± 6.2 |
| 3 | | 0 | 0.1 ± 0.2 | 0.4 ± 0.6 | 4.9 ± 6.3 |
| 4 | | 0 | 0 | 0 | 2.5 ± 2.6 |
| 5 | | 0 | 0 | 0.2 ± 0.3 | 1.5 ± 1.1 |
| 1 | 15 | 89.4 ± 3.4 | 87.6 ± 1.1 | 89.3 ± 2.3 | 86.7 ± 1.7 |
| 2 | | 9.7 ± 5.9 | 12.1 ± 10.8 | 43.4 ± 1.1 | 36.8 ± 13.7 |
| 3 | | 1.1 ± 1.6 | 2.0 ± 3.1 | 9.8 ± 3.5 | 7.4 ± 5.5 |
| 4 | | 0 | 2.6 ± 4.1 | 4.1 ± 3.7 | 3.7 ± 3.3 |
| 5 | | 0 | 0 | 1.8 ± 2.0 | 0.2 ± 0.4 |
| 1 | 30 | 86.9 ± 1.2 | 86.3 ± 2.2 | 92.7 ± 8.7 | 86.1 ± 1.6 |
| 2 | | 12.9 ± 8.2 | 12.4 ± 8.1 | 41.3 ± 5.3 | 42.9 ± 1.2 |
| 3 | | 1.2 ± 2.4 | 3.2 ± 5.0 | 14.3 ± 9.2 | 24.2 ± 11.9 |
| 4 | | 0 | 2.5 ± 3.1 | 6.5 ± 7.6 | 7.9 ± 8.5 |
| 5 | | 0 | 0 | 1.5 ± 3.1 | 0.4 ± 0.9 |

[a]Means ± standard deviations are presented.

Since similar patterns of seed loss occurred at all sites in the first three years, climatic differences in temperature or rainfall were not believed to be responsible for differences in seed loss between burial locations. The region is semiarid and relatively uniform in climate. Seventy-five to 80% of the annual precipitation falls during the growing season from April to October. Average annual precipitation ranges from 300 to 560 mm and average annual temperatures range from 6.7 to 13.9 C, although extremes of −34.0 to 46.1 C have been reported.

Most Genoa seed also were lost from soil in the first three years of the experiment (Table 5). Loss of surviving seed was slower in the fourth and fifth years than in the first three years. At the 5-cm burial depth, there was total loss of Genoa seed at one and two sites in the third and fourth years, respectively. By the fifth year there was total loss of seed at all depths at two of four sites; less than 1.8 ± 2.0% of the Genoa seed remained at either of the two other sites. Genoa seed were most persistent at Akron, CO, and Sidney, NE. Most rapid loss of Genoa seed occurred at 5 cm and decreased with depth (Table 5), as observed for Limon seed (Table 4).

Other studies have demonstrated that geographic location modifies seed persistence of halogeton [*Halogeton glomeratus* (Stephen ex Bieb.) C.A. Mey. # HALGL] (29), shattercane [*Sorghum bicolor* (L.) Moench # SORVU] (3), and wild oats (*Avena fatua* L. # AVEFA) (27). The reasons why location modifies seed survival have never been studied. Greater seed survival at greater burial depths also was observed in wild oats (1, 26, 34), common crupina (*Crupina vulgaris* Cass. # CJNVU) (32), common lambsquarters (*Chenopodium album* L. # CHEAL) (26), halogeton (29), barnyardgrass [*Echinochloa crus-galli* (L.) Beauv. # ECHCG], yellow foxtail [*Setaria glauca* (L.) Beauv. # SETLU], and green foxtail [*Setaria viridis* (L.) Beauv. # SETVI] (6). While deeper buried jointed goatgrass seed tended to persist longer than shallowly buried seed, the influence of depth on seed survival was not as pronounced as with several of the previously mentioned species. There also were some inconsistencies in this trend with location (Tables 4 and 5).

Two-year-old Genoa seed were 43.8 ± 9.1% germinable (mean ± SD) and freshly harvested Limon seed were 11 ± 2.2% germinable at the start. While Limon seed survival decreased each year at the 5-cm depth (Table 4), seed germinability either remained the same or increased in the first

*Table 6*. The germination of jointed goatgrass seed of the Limon seed source as a percentage of the average initial number of seed that were buried as influenced by location, depth of burial, and year after burial. At the start, the seed were 11.0 ± 2.2% germinable.

| Year | Depth of burial | Fort Collins | Rocky Ford | Akron | Sidney | Tribune |
|---|---|---|---|---|---|---|
| | (cm) | (%)[a] | | | | |
| 1 | 5 | 14.4 ± 4.1 | 11.8 ± 1.3 | 13.6 ± 5.7 | 14.8 ± 7.2 | 27.6 ± 3.1 |
| 2 | | 0.2 ± 0.3 | 1.1 ± 0.8 | 15.5 ± 3.4 | 12.8 ± 7.4 | 20.7 ± 5.4 |
| 3 | | 0 | 0 | 0.3 ± 0.4 | 0.3 ± 0.4 | 0.2 ± 0.5 |
| 4 | | 0.1 ± 0.2 | 0 | 0.2 ± 0.5 | 0.1 ± 0.2 | 0 |
| 5 | | 0 | 0 | 0 | 0 | 0 |
| 1 | 15 | 11.5 ± 2.3 | 13.8 ± 2.1 | 20.2 ± 4.3 | 15.6 ± 3.1 | 33.4 ± 2.7 |
| 2 | | 1.3 ± 2.5 | 0 | 16.7 ± 3.7 | 18.0 ± 6.1 | 27.0 ± 6.7 |
| 3 | | 0 | 0 | 6.0 ± 5.8 | 1.9 ± 2.5 | 15.9 ± 7.6 |
| 4 | | 0 | 0 | 0 | 0 | 1.1 ± 2.3 |
| 5 | | 0 | 0 | 0 | 0 | 0 |
| 1 | 30 | 6.7 ± 2.4 | 17.0 ± 7.8 | 19.8 ± 5.7 | 15.8 ± 0.3 | 34.6 ± 6.4 |
| 2 | | 0.3 ± 0.4 | 1.4 ± 1.6 | 20.8 ± 4.3 | 20.9 ± 3.9 | 34.8 ± 2.9 |
| 3 | | 0.2 ± 0.5 | 0 | 3.9 ± 2.8 | 5.7 ± 5.4 | 22.3 ± 10.7 |
| 4 | | 0 | 0 | 0 | 0.1 ± 0.2 | 3.3 ± 6.6 |
| 5 | | 0 | 0 | 0.2 ± 0.5 | 0.1 ± 0.2 | 9.5 ± 7.5 |

[a]Means ± standard deviations are presented.

year of the experiment before beginning to decrease in either the second or third year (Table 6). By the third year, less than 0.3 ± 0.4% of the initial number of Limon seed buried at 5 cm were germinable. By five years, no Limon seed were germinable at the 5- and 15-cm depths at all locations. At three of five locations, seed were germinable at 30 cm after five years. As burial depth increased, germinability tended to increase, especially at Tribune, KS. This reflected both greater seed survival of more deeply buried seed and their loss of dormancy. As the number of seed decreased, the proportion of seed that germinated increased when expressed as a percentage of seed that remained (data not presented).

Not only were Genoa seed more germinable than Limon seed at the start (Table 6), but Genoa seed tended to remain germinable slightly longer (Table 7). Genoa seed survival and germinability were always smaller after five years compared to the start. Almost total loss of germinable seed was observed at four years at all burial depths at Fort Collins and Rocky Ford, CO. Germinability of Genoa seed was strongly influenced by location and year as burial depth increased (Table 7), unlike Limon seed (Table 6). However, germinability did not increase consistently with depth at all locations for all years.

Limitations to our experimental approach must be considered: 1) Conditions that limit germination often enhance seed survival (28). The seed packets used in this study may have modified seed persistence. However, this possibility seems unlikely because the packets did not modify germination of buried seed (unpublished results), even though soil was not added to each packet, as has been done by some others (6, 29, 30). The mesh packets permitted normal germination while retaining the seed. The packets' large mesh size also permitted seed exposure to the soil environment. While earthworms, small insects or insect larvae, and other soil microflora or microfauna may have entered the packets, the seed were protected from large insects, birds, and rodents. Seed predators may be responsible for significant losses of surface seed under field conditions (4, 18, 22, 33). 2) Seed persistence might be longer in seed packets than in soil because the seed were not disturbed in the soil profile. Roberts (28) summarized several field studies in which either tillage or soil disturbance simulating tillage significantly increased the rate of seed loss from soil. Thus, under stubble-mulch tillage, which is common in the Central Great Plains, jointed goatgrass seed is likely to be less persistent than reported here. 3) Depth control of packets in soil was not absolutely assured (range ± 1 cm) as others have done by suspending seed packets in columns of soil (3). The latter method was deemed unsuitable because it does not provide full contact with the surrounding soil environment and required soil disturbance. 4) Because seed packets were sampled at yearly intervals, information was not obtained on seasonal changes in seed persistence or germinability. 5) The reasons for differences in seed loss were not investigated, although germination is thought to be chiefly responsible for decreases in surviving seed of other weed species (28). These considerations apply to most other studies of seed burial which usually were set up like this experiment.

*Table 7.* The germination of jointed goatgrass seed of the Genoa seed source as a percentage of the average initial number of seed that were buried as influenced by location, depth of burial, and year after burial. At the start, the seed were 43.8 ± 9.1% germinable.

| Year | Depth of burial | Fort Collins | Rocky Ford | Akron | Sidney |
|---|---|---|---|---|---|
| | (cm) | | (%)[a] | | |
| 1 | 5 | 24.6 ± 6.2 | 26.7 ± 2.2 | 23.7 ± 3.3 | 15.0 ± 6.5 |
| 2 | | 5.4 ± 6.1 | 9.8 ± 2.6 | 21.4 ± 8.8 | 18.2 ± 8.6 |
| 3 | | 0 | 0.1 ± 0.2 | 0.4 ± 0.4 | 3.5 ± 4.9 |
| 4 | | 0 | 0 | 0 | 2.4 ± 2.4 |
| 5 | | 0 | 0 | 0.1 ± 0.2 | 1.3 ± 1.1 |
| 1 | 15 | 19.9 ± 7.1 | 30.1 ± 8.1 | 31.5 ± 4.4 | 11.9 ± 1.6 |
| 2 | | 6.0 ± 4.8 | 10.9 ± 11.2 | 27.2 ± 5.0 | 25.1 ± 6.8 |
| 3 | | 0.5 ± 1.1 | 1.9 ± 2.9 | 7.7 ± 4.7 | 4.8 ± 2.4 |
| 4 | | 0 | 0 | 1.1 ± 2.2 | 0 |
| 5 | | 0 | 0 | 1.6 ± 1.9 | 0.2 ± 0.4 |
| 1 | 30 | 9.2 ± 2.3 | 31.9 ± 5.9 | 34.2 ± 3.5 | 8.9 ± 3.4 |
| 2 | | 8.1 ± 5.6 | 9.8 ± 7.2 | 31.4 ± 5.6 | 33.1 ± 2.1 |
| 3 | | 0.9 ± 1.8 | 2.7 ± 4.2 | 9.4 ± 7.1 | 19.9 ± 10.8 |
| 4 | | 0 | 0 | 0 | 0 |
| 5 | | 0 | 0 | 1.1 ± 2.2 | 0.2 ± 0.4 |

[a]Means ± standard deviations are presented.

This experiment demonstrates that jointed goatgrass may have type III seed reserve behavior (28). Type III seed persistence is intermediate between very short-lived and very persistent seed. Type III seed populations are polymorphic; a portion of the soil seed reserve germinates early, whereas the rest may persist for years. Many weed scientists assume that most weed seed persist for long periods in soil. However, seed of many grass weeds often survive for only two or three years in field soil. For example, seed of cheat (*Bromus secalinus* L. # BROSE) (5), poverty brome (2, 15), soft brome (*Bromus mollis* L. # BROMO) (21), downy brome (*Bromus tectorum* L. # BROTE) (23), wild oat (21, 34), quackgrass [*Agropyron repens* (L.) Beauv. # AGRRE], Virginia wild rye (*Elymus virginicus* L. # ELYVS), *E. canadensis* L., *E. triticroides* Buckl., meadow fescue (*Festuca pratensis* Hads. # FESPR) (16), orchardgrass (*Dactylis glomerata* L. # DACGL), and perennial ryegrass (*Lolium perenne* L. # LOLPE) (19) were all lost from soil or were not viable in three years or less. Several of these transient species become problems in continuous wheat or wheat-fallow rotations even though their seed have short persistence, like jointed goatgrass. Because most jointed goatgrass spikelets are found near the soil surface (Table 2), the rapid loss of seed at the 5-cm depth (Table 4) is important. Most jointed goatgrass seed at 5 cm were lost in three years with some variation depending upon location. Thus, a three-year fallowing of fields infested with jointed goatgrass should reduce or eradicate populations if new seed are not introduced. Weed control on fallowed land can be done mechanically by tillage or by applying various herbicides that control jointed goatgrass and prevent new seed production (9, 10, 11, 14). Only crop seed free of jointed goatgrass should be planted, and combines should be cleaned before harvest to prevent introduction of new jointed goatgrass seed.

### ACKNOWLEDGMENTS

We thank R. Hoerauf for his technical help. The secretarial help of J. Schmidt, the photographic assistance of T. Hlavaty, and the statistical assistance of R. Khattree and B. Mangus are appreciated.

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