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Ecological Characteristics of Three Winter Annual Grasses[1]

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Abstract: Producers rely on cultural practices to manage downy brome, jointed goatgrass, and feral rye in winter wheat because there are no effective herbicides for in-crop control. This study characterized seedling emergence, growth, and development of these winter annual grasses, with the goal of suggesting or improving cultural control strategies. Feral rye seedlings emerged within 4 wk, whereas downy brome and jointed goatgrass seedlings emerged over a 10-wk period. Emergence patterns of these grasses suggest that delay of winter wheat planting may be effective in reducing feral rye densities, but this strategy most likely will be ineffective with downy brome or jointed goatgrass. Downy brome began anthesis 1 to 2 wk earlier than the other two grasses and winter wheat. Both downy brome and jointed goatgrass were shorter than winter wheat during the growing season, whereas feral rye was at least as tall as wheat. Producers mow infested wheat to prevent weed seed production, but this practice may not be effective with jointed goatgrass and downy brome because of their short stature and downy brome's earlier development. Conversely, mowing has potential in preventing feral rye seed production. The grasses produced between 340 and 770 seeds/plant.

Nomenclature: Downy brome, *Bromus tectorum* L. #[3] BROTE; feral rye, *Secale* spp.; jointed goatgrass, *Aegilops cylindrica* Host # AEGCY; winter wheat, *Triticum aestivum* L. 'TAM 107.'

Additional index words: Cultural practices, plant development, seedling emergence, AEGCY, BROTE.

Abbreviations: GDD, growing degree day.

INTRODUCTION

Downy brome, jointed goatgrass, and feral[4] rye are common weeds in the winter wheat-fallow region of the Central Great Plains (Wicks and Smika 1990). With few herbicides that effectively control these weeds in winter wheat (Holtzer et al. 1996), producers rely on cultural practices to reduce weed densities in wheat as well as minimize weed interference and grain yield loss. To reduce weed densities, producers insert summer crops in the rotation to lengthen time between wheat crops and favor natural decline of the weed seedbank (Anderson 1994). A second practice is to delay wheat planting to allow more time for weed seedlings to emerge, which are then controlled by tillage or herbicides (Wicks 1984).

Cultural practices that reduce weed interference in wheat include N placement (Anderson 1997; Miller 1990), increased seeding rates (Koscelny et al. 1991), narrow row spacing (Solie et al. 1991), or tall winter wheat cultivars (Challaiah et al. 1986). These strategies not only increase the competitiveness of wheat, but also reduce weed seed production (Challaiah et al. 1986; Koscelny et al. 1990). For example, combining N placement and increased seeding rate with a tall wheat cultivar reduces seed production of feral rye and jointed goatgrass by more than 40% (Anderson 1997).

The major drawback with cultural strategies is erratic performance. Delayed planting of winter wheat reduces downy brome population in-crop only 1 yr out of 6 (Anderson 1996), because downy brome seedling emergence is erratic (Anderson 1989). Planting winter wheat in narrow row spacing (15 vs. 30 cm) is effective with brome species only 60% of the time (Koscelny et al. 1990; Solie et al. 1991), whereas increasing the seeding rate of wheat fails to favor wheat over brome species 1 yr out of 4 (Ferreira et al. 1990; Koscelny et al. 1991).

When cultural practices fail to control these weeds, producers usually incur economic losses (Ferriera et al. 1990; Justice et al. 1993). For example, delaying winter wheat planting has detrimental consequences, such as reduced grain yield (Musick and Winter 1994) and more

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

[4] Feral is defined as having escaped from domestication or cultivation and become wild.

weeds in wheat and other future crops (Wicks et al. 1989). Furthermore, winter wheat planted outside of its optimum planting range is more susceptible to root diseases (Cook and Veseth 1991).

A better knowledge of weed ecology will help producers integrate cultural practices in their weed management strategies (Sagar and Mortimer 1976; Staniforth and Wiese 1985), especially if weed ecology information is incorporated in weed management models (Radosevich and Ghersa 1992). Decision aid models with an ecological component guide weed management in corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] (Swinton and King 1994), and a decision aid model is being developed to manage jointed goatgrass in wheat (Maxwell et al. 1996). With ecological data of weeds, these models can predict effect of cultural practices on weed interference and population dynamics.

Growth patterns of downy brome and jointed goatgrass have been reported (Anderson 1993; Ball et al. 1995), but not with feral rye. Therefore, this study compared the ecological characteristics of feral rye with downy brome and jointed goatgrass, with the goal of identifying vulnerable stages of their life cycles and suggesting cultural strategies for control.

MATERIALS AND METHODS

General Procedures. Field and greenhouse studies were conducted between 1992 and 1995 at Akron, CO. During the field studies, yearly precipitation ranged from 325 to 530 mm, averaging 428 mm. The long-term (90-yr) yearly precipitation averages 419 mm. Average air temperature during the winter wheat growing season is 10 C for September through November, −3 C for December through February, and 11 C for March through June. Soil was a Weld silt loam (Aridic Paleustoll) with 1.2% organic matter.

Greenhouse studies were conducted each year between November 1 and April 1. The day and night temperatures averaged 25 C and 16 C, respectively, and daylight during this period ranged from 10 to 12 h. Soil was a Valent sand (Ustic Torripsamment) with 0.7% organic matter. Pots were 15 cm diam and 15 cm deep filled with 1,300 g of soil.

Unless noted otherwise, experimental design for all studies was a randomized complete block. Differences among treatments were determined with ANOVA, and when the *F* test was significant, means were compared with LSD at the 5% level of probability. A year by treatment interaction did not occur with any study, thus all data were averaged across years.

Seedling Emergence Field Study. Six 1-m^2 sites were marked in wheat stubble on August 15 in 1993, 1994, and 1995. At each site, 200 seeds of downy brome and feral rye and 100 spikelets[5] of jointed goatgrass were placed on the soil surface. Seed was collected from a local seed cleaning plant. The sites were tilled with a sweep plow to incorporate seeds.

Seedling emergence by species was recorded weekly at each site from initial emergence through early December. In all years, emergence began in August or September. Seedlings were pulled and removed after counting. Emergence pattern for each species was developed by converting seedling emergence per week into a percentage of total emergence for each year. Data across years were averaged by weekly intervals, with one standard deviation derived from yearly averages for each week. Emergence curves were developed by cubic spline interpolation.[6]

Seedling Development Greenhouse Study. Eight seeds of each weed species were planted in separate pots. Planting depth was 2.5 cm, with 15 g (40 kg N/ha) ammonium nitrate placed 3 cm below the seeds. Soil water was maintained at 80% field capacity by daily weighing and watering. After initial watering, pots were capped with aluminum foil for 4 d to allow seeds to imbibe water. After emergence, seedlings were thinned to four plants per pot. Plant development was recorded daily, starting with the first leaf, and continued until the third tiller emerged. Air temperature was recorded hourly by a data logger, with thermocouples placed 2 cm above the soil surface in one pot randomly placed in each replication. The study was repeated four times, with four replications in each study. For each pot, data were averaged over plants.

Rate of development was related to growing degree day (GDD) accumulation (Ball et al. 1995). For regression analysis, the developmental stages, one-leaf, two-leaf, one-tiller, two-tiller, and three-tiller, were evaluated as whole numbers from one to five. With all species, the first tiller appeared before the third leaf was visible. Growing degree days were calculated from daily air temperatures using a base temperature of 0 C (Dotray and Young 1993; McMasters and Smika 1988).

Crown Root Development Greenhouse Study. Eight seeds of each species were planted in separate pots. TAM 107 winter wheat was included for comparison. Establishment procedures were identical to those out-

[5] Jointed goatgrass spikelets, on average, contain two seeds (Donald and Ogg 1991).

[6] SigmaPlot. Jandel Scientific, San Rafael, CA 94901.

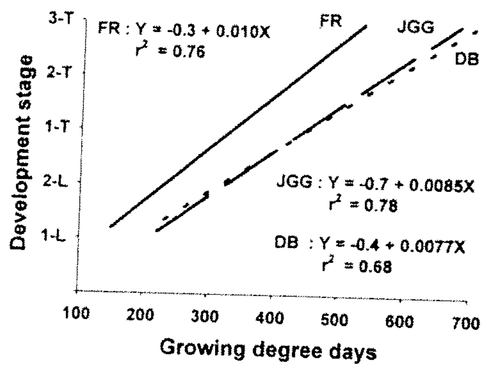

Figure 2. Seedling development of downy brome, jointed goatgrass, and feral rye as related to growing degree days in the greenhouse. Developmental stages were: 1-L, one-leaf; 2-L, two-leaf; 1-T, one-tiller; 2-T, two-tiller; 3-T, three-tiller.

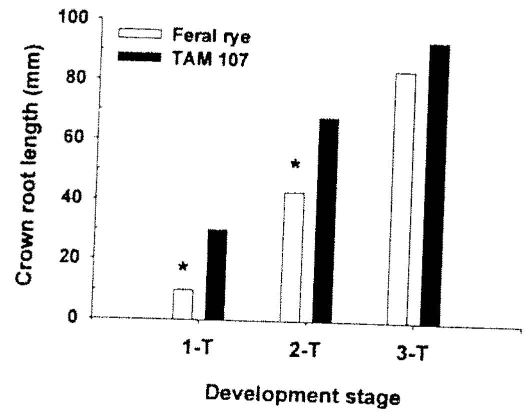

Figure 3. Crown root length of feral rye and TAM 107 wheat at three developmental stages in a greenhouse study. An * indicates that feral rye differed (LSD at the 0.05 level) from TAM 107 within that developmental stage. Developmental stages were: 1-T, one-tiller; 2-T, two-tiller; 3-T, three-tiller.

has been ineffective with downy brome because of its erratic seedling emergence in dry years (Anderson 1996) and most likely will be ineffective with jointed goatgrass because its emergence pattern is similar to downy brome. Delay of winter wheat planting may be effective with feral rye because of its compressed emergence pattern.

Producers should be cautious with implementing delay of planting for winter annual grass control because planting winter wheat outside of its optimum period can be detrimental. Grain yield is reduced 4 to 8% for each week delay after the optimum period (Musick and Winter 1994), and if weeds emerge after planting, severe economic losses can result (Justice et al. 1993).

Seedling Development. Downy brome and jointed goatgrass developed similarly, but both species developed slower than feral rye (Figure 2). Feral rye's first tiller appeared after 330 GDD, whereas downy brome and jointed goatgrass required more than 440 GDD before the first tiller emerged. Species that tiller more rapidly accrue a competitive advantage (Ball et al. 1995; Harper 1977). Feral rye's rapid seedling development may contribute to its competitiveness; it reduces wheat yield three times more than either downy brome or jointed goatgrass on a per-plant basis (Anderson 1994).

Performance of postemergence herbicides is influenced by plant development (Harrison et al. 1985). Graminicide effect is reduced when grasses are tillering compared with pretillering at time of application (Derr et al. 1985). If biotechnological advances lead to graminicide-tolerant winter wheat, these developmental relationships should be helpful in timing herbicide applications.

Crown Root Growth. Downy brome, jointed goatgrass, and winter wheat did not differ in root length (data not shown); however, feral rye root growth was slower than wheat (Figure 3). When the first tiller was visible, feral rye's crown roots were less than one-third the length of winter wheat. By the three-tiller stage, crown root length did not differ between the two species. This root growth response is surprising, because it contrasts with feral rye seedlings developing faster than the other grasses (Figure 2).

This response suggests a possible control tactic for feral rye with soil-active herbicides. For example, metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one] selectively controls downy brome in winter wheat if crown roots of wheat are longer than downy brome at time of application.[8] Integrating feral rye emergence time and crown-root development with timing of soil-applied herbicides may lead to possible control options.

Field Development and Growth. Producers can prevent seed production of grasses by mowing infested areas of their winter wheat fields, provided the plants are cut before viable seeds develop. With downy brome (Upadhyaya et al. 1986) and wild oat (*Avena fatua* L.) (Aldrich 1984), viable seeds can be produced by late anthesis.

Downy brome reached anthesis 560 GDD after March 1 (Table 1), which occurred during the first week of May each year. Feral rye flowered 110 GDD later than downy brome, whereas jointed goatgrass flowered 750 GDD after March 1. Jointed goatgrass required 34% more GDD to reach anthesis compared to downy brome. Wheat and jointed goatgrass developed similarly (data not shown), as found previously (Anderson 1993; Dotray and Young 1993). Mowing effectiveness for control also is related

[8] Lexone Label. E. I. Du Pont De Nemours and Co., Wilmington, DE 19898.

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