EB1932

Jointed Goatgrass Ecology

Jointed goatgrass management in winter wheat has been difficult because the genetics and growth patterns of these two species are similar. Knowledge of jointed goatgrass growth characteristics can help producers select effective management strategies, as some attributes of jointed goatgrass respond to control practices. In this bulletin, we describe the ecology of jointed goatgrass at various stages of its life cycle, and then relate these characteristics to the effectiveness of cultural practices used for managing jointed goatgrass.

Plant Identification

Identifying jointed goatgrass in the field challenges producers because seedlings of jointed goatgrass resemble winter wheat seedlings in appearance. Two prominent traits aid growers in distinguishing between seedlings of the two species:

- First, jointed goatgrass seedlings have evenly spaced hairs lining the leaf blade margin (Figure 1)—these hairs usually are not present in winter wheat. If hairs appear on winter wheat leaves, they are longer and randomly spaced.

- Second, the flower structure of mature jointed goatgrass—referred to as a spikelet or a joint—is distinct. The outer spikelet glumes fuse together and enclose one to three seeds, giving the spikelet an appearance of a cylindrical joint (Figure 2); hence, the name jointed goatgrass. After germination, jointed goatgrass seedlings usually remain attached to the spikelet (Figure 3). Removing soil from around the seedling to expose the spikelet confirms whether the seedling is jointed goatgrass.

Spikelets resemble pieces of wheat straw. They are easy to overlook in winter wheat seeds (Figure 4). However, producers can quickly determine if jointed goatgrass is present by placing a seed sample in water; jointed goatgrass spikelets usually float, whereas wheat kernels rarely do.

Figure 1. Hairs present on the edge of a jointed goatgrass leaf.

Figure 2. Jointed goatgrass spikelets beside seeds of winter wheat.

Seeds in Soil

In wheat fields infested with jointed goatgrass the soil contains jointed goatgrass seeds and spikelets, which together form the soil seed bank. Spikelets and seeds can invade a field in several ways (e.g., with crop seed at planting time, or transported by machinery such as combines). After the initial invasion, seed bank increases come mainly from jointed goatgrass plants producing seeds during the growing season, rather than from a seed source outside the field boundary.

When in soil, weed seeds can germinate, remain dormant, or die. Seeds can die naturally or are consumed by microbial communities in the soil or predators such as field mice, insects, or birds. The decline of live seed numbers in the seed bank follows a typical trend (Figure 5). One year after entering the seed bank, more than 80% of jointed goatgrass seeds are alive. Two years later, approximately 30% are alive, and by the third year, less than 5% of the original population of jointed goatgrass seeds remain alive. Jointed goatgrass seeds may survive longer in drier soil conditions, yet their numbers still decline more rapidly than seeds of other weed species.

The rapid decline in live seeds over time explains why including alternate crops in rotation with winter wheat reduces density of jointed goatgrass in future wheat. The longer interval between winter wheat crops favors the natural decline of the seed bank. Subsequently, fewer plants infest the next winter wheat crop. Producers must control jointed goatgrass during this interval. Any seeds produced will replenish the seed bank and reverse the natural decline of the weed seed population.

Producers observing extensive seedling emergence in shallowly tilled fields often ask whether tillage helps deplete the jointed goatgrass seed bank. Under some conditions, emergence of jointed goatgrass seedlings can double in the first year following tillage, compared with emergence in no-till fields. However, seeds buried by tillage are protected from environmental extremes and predators, and they survive longer. Research has shown long-term survival of jointed goatgrass in the seed bank does not differ between tilled and no-till systems. Increased germination prompted by tillage apparently offsets increased mortality among seeds lying on the soil surface in no-till.

A drawback with tillage is that each operation buries crop residues and encourages erosion. In semiarid regions, crop yield, especially of summer annuals, is greater when crop residues remain on the soil surface. Residues keep soil water from evaporating, thereby holding more soil moisture available for crop growth. Producers in these regions must weigh the possible

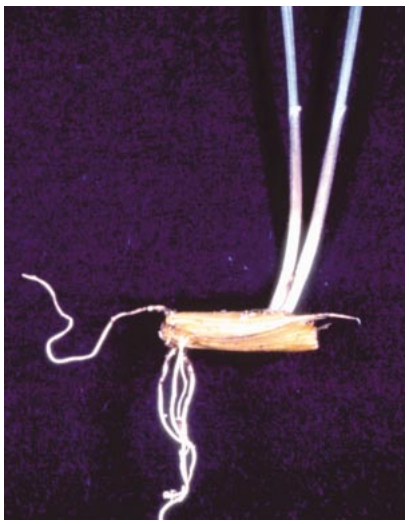


Figure 3. Two jointed goatgrass seedlings emerging from a single spikelet.

Figure 4. Jointed goatgrass spikelets in grain of winter wheat.

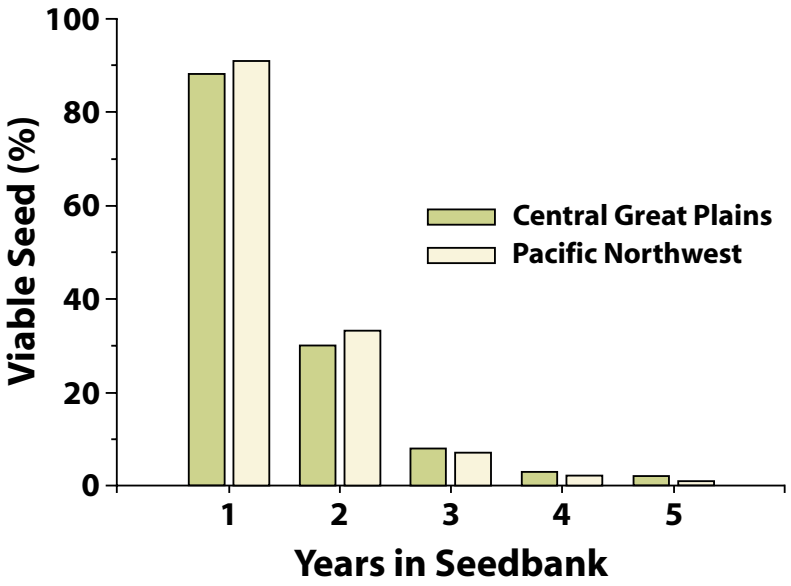


Figure 5. Longevity of live seeds of jointed goatgrass in soil. Research conducted at sites in the Central Great Plains and Pacific Northwest, where rainfall ranged from 15 to 18 inches per year.

short-term benefit of tillage for managing jointed goatgrass against the detrimental effect of tillage on crop yield.

Producers can burn postharvest crop residues to kill jointed goatgrass seeds. Although burning may help on small areas of dense infestation, two aspects of this strategy limit its general effectiveness. First, large quantities of crop residue (7,000 lbs of crop residue per acre or more) must be burned to reach lethal temperatures. Second, only jointed goatgrass seeds lying on the soil surface are killed; seeds buried in soil are protected from the lethal heat.

Seedling Emergence

Jointed goatgrass generally emerges during cool weather. Peak emergence occurs from September through early November, with a secondary flush of seedlings emerging in late winter and early spring. Seedlings can emerge in any of the cooler months. In one study, almost all seedlings emerged within a 3-week period in September of the first year; the following year, seedlings emerged every month from August through April. Germination relates closely to precipitation; dry periods delay germination until more favorable conditions develop.

To encourage seedling emergence, producers may till fields 2 to 3 weeks before planting winter wheat. If soil moisture is adequate, seedlings emerge and can easily be controlled prior to planting wheat. However, this practice is not consistently effective because precipitation is erratic in semiarid regions and tillage can rapidly dry out the soil. Also, tillage buries seeds at various depths in soil, prolonging the seedling emergence period. Since seedlings of deeply buried seeds may not emerge until after wheat has been planted, these plants will not be controlled by tillage.

Producers may delay planting winter wheat to allow the emergence of more jointed goatgrass seedlings. This approach is typically ineffective—not only because of the erratic nature of jointed goatgrass emergence, but also because delayed planting usually reduces winter wheat yields. This trend was demonstrated with downy brome, where delayed planting reduced downy brome density in winter wheat only one year out of six; yet winter wheat yield was reduced every

year of the study due to the later planting date. Producers should emphasize other cultural practices to manage jointed goatgrass rather than planting winter wheat outside of its optimum planting period.

Moldboard plowing can minimize seedling emergence because jointed goatgrass cannot emerge if buried at depths of more than 6 inches. This approach also has negative aspects. Plowing damages soil health by burying crop residues and reducing organic matter levels, making the soil more susceptible to erosion and less productive. This strategy may be useful only for small areas of dense infestations. Because seeds survive longer when buried deep in soil, plowing in subsequent years will bring viable seeds back to the soil surface.

An intriguing trend appeared in crop rotation studies in the Central Great Plains. Jointed goatgrass seed density in soil declined more rapidly in winter wheat–sunflower–fallow or winter wheat–corn–fallow than it did in a winter wheat–proso millet–fallow rotation. This difference among rotations relates to seedling emergence in late summer. An earlier study found fall emergence of jointed goatgrass was four times greater in corn or sunflower compared with emergence in proso millet or sorghum. These crops differ in rooting patterns; i.e., proso millet and sorghum roots develop close to the soil surface, thus drying out topsoil and preventing weed germination. The main lesson from these studies: *alternative crops can vary in the degree to which they influence jointed goatgrass germination and, subsequently, long-term seed bank levels.*

Plant Development

Development of jointed goatgrass shoots or roots resembles that of winter wheat, reflecting their common ancestry and genetics. One difference between the two species is that anthesis (period of flowering) for jointed goatgrass is longer than for winter wheat. This trait enables jointed goatgrass to adjust to environmental stress during flowering and ensures seed production. Jointed goatgrass seeds develop rapidly after pollination occurs. Studies showed a small percentage of seeds can germinate even if the plant is controlled shortly after flowering. About 50% of seeds are viable by the early milk stage.

Producers can reduce jointed goatgrass seed production in heavily infested wheat by spraying with nonselective herbicides. Although the crop is lost, this practice prevents jointed goatgrass seed production, provided plants are killed before the boot stage of development. Compared with burning crop residues or moldboard plowing, this strategy is more suitable for managing small areas of dense infestations because it is less damaging to the environment.

A note of caution when feeding hay infested with jointed goatgrass seeds: *livestock spread the seeds because the digestive system of cattle does not kill all seeds.* Producers can avoid this spread of seeds by processing feed with a fine-grind hammermill, as processing injures or destroys seeds and prevents germination.

Interference

Jointed goatgrass competes with wheat for essential resources such as water, light, and nutrients. To aid producers in assessing impact of jointed goatgrass, researchers have sought to define the relationship between jointed goatgrass density and yield loss of winter wheat. That relationship has been difficult to quantify because multiple factors—winter wheat cultivar, density of both species, time of jointed goatgrass emergence relative to winter wheat, and environmental conditions—influence the interaction between jointed goatgrass and winter wheat.

Research demonstrated this variability in a field trial. In one year 25 plants per square yard reduced wheat grain yield 30%. The following year the same plant density reduced yield less

than 5%. A general guideline for producers to estimate possible yield loss: *one jointed goatgrass plant per square yard reduces grain yield approximately 1%.*

A key component of interference is how weed growth coincides with crop growth, i.e., the earlier jointed goatgrass emerges relative to wheat, the more damage it causes. When jointed goatgrass emerged with wheat, 18 plants per square yard reduced grain yield of winter wheat 27% (Figure 6). In contrast, jointed goatgrass emerging 42 days after winter wheat reduced yield 16%, and only 6% when jointed goatgrass emerged in the spring (March).

A second component of yield loss is how long jointed goatgrass competes with winter wheat.

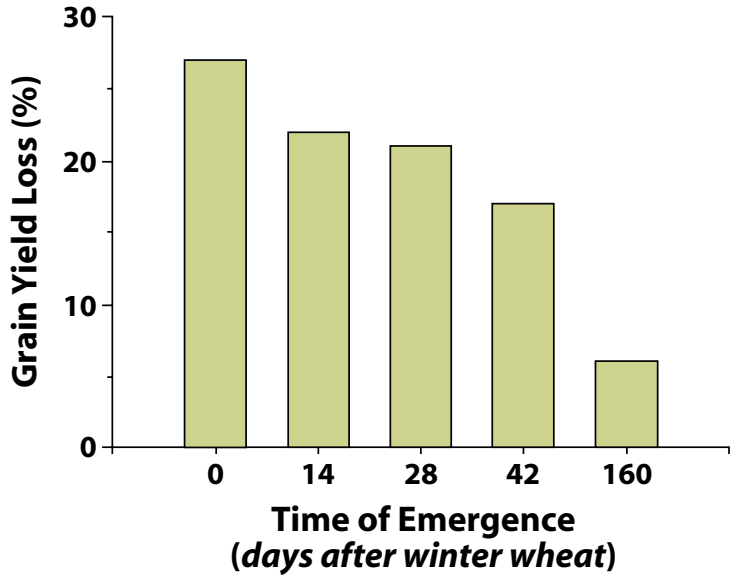


Figure 6. Yield loss of winter wheat as affected by time of emergence of jointed goatgrass. Winter wheat was planted in late September; jointed goatgrass density was 18 plants per square yard.

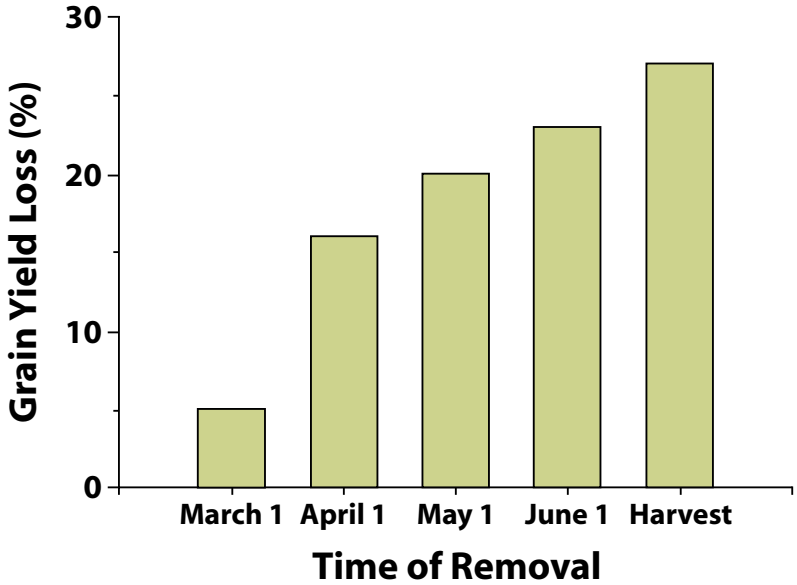


Figure 7. Yield loss of winter wheat as affected by time of removal of jointed goatgrass. Jointed goatgrass density was 18 plants per square yard.

When jointed goatgrass was removed by March 1, yield loss was 5%, whereas removing jointed goatgrass on April 1 increased yield loss to 15% (Figure 7). These yield loss trends suggest the optimum time to control jointed goatgrass is late fall or early spring. This guideline will help producers using postemergent herbicides such as Beyond™ (imazamox), which controls jointed goatgrass in imazamox-tolerant wheat cultivars.

Another principle for designing management strategies suggests any crop or weed plant that captures resources first gains a competitive advantage. In that vein, producers can take steps to improve the competitiveness of winter wheat with jointed goatgrass. For example, banding N fertilizer with winter wheat seed at planting reduces jointed goatgrass interference 10% to 15% compared with N applied broadcast. Banding allows winter wheat to reach N fertilizer first.

Also, winter wheat cultivars differ in their competitiveness with jointed goatgrass. Cultivar characteristics favoring wheat over jointed goatgrass include early fall and spring growth, higher tillering capacity, and taller plants. In Washington, tall cultivars having early spring growth reduced jointed goatgrass biomass in some years 20% to 40% compared with other cultivars. Increasing seeding rates and reducing row spacing likewise give winter wheat a competitive advantage over jointed goatgrass.

Seed Production

Jointed goatgrass growing in winter wheat may produce anywhere from a few to more than 200 spikelets per plant (each spikelet contains one to three seeds). If growing without competition (e.g., in areas of winter-killed wheat), jointed goatgrass can produce 3,000 seeds or more per plant.

Seed production and flowering by jointed goatgrass are affected by cold temperature exposure—a process known as vernalization. Plants are easily vernalized when established in the fall. Those germinating and emerging in the spring also can be vernalized in some situations. Jointed goatgrass can emerge and produce viable seeds in early planted crops such as spring wheat or barley, reducing the effectiveness of using spring crops as a cultural practice to manage jointed goatgrass.

> ***A winter wheat management system incorporating N fertilizer banded by the wheat seed, a tall cultivar, and higher seeding rate reduced seed production of jointed goatgrass 45%***

Producers can reduce jointed goatgrass seed production in winter wheat by using several cultural practices together. A management system comprising 1) placing N fertilizer with wheat seeds at planting, 2) planting a competitive cultivar, and 3) using a higher seeding rate (140% of conventional rates), reduced seed production of jointed goatgrass 45% (Figure 8). This competitive advantage was even greater when jointed goatgrass emerged 3 weeks after winter wheat, reducing jointed goatgrass seed production nearly 60%. Employing a single cultural practice has a lesser effect, e.g., banding N fertilizer reduced seed production only 10% (Figure 8).

A key component of long-term population growth of jointed goatgrass may be dispersal of its seeds during harvest. In Australia, downy brome population growth and spread increased 16-fold when a combine dispersed seed at harvest. Since dense jointed goatgrass patches are often localized in fields, harvesting these areas separately from weed-free sections of a field will minimize seed dispersal. Cleaning combines thoroughly after harvesting infested fields also will reduce spread.

Although not appropriate for large field areas, eliminating small, dense areas of infestations in fields by using nonselective herbicides will prevent dispersal of jointed goatgrass during harvest. This strategy also helps minimize population growth over years.

Cultural Strategies Guided by Jointed Goatgrass Ecology Improve Management

Certain growth characteristics of jointed goatgrass can provide the foundation for effective management. Because jointed goatgrass reproduces only by seed, any practice that reduces seed production will slow its spread. Once a field is infested with jointed goatgrass, the first goal is to lower the soil seed bank density. Lengthening the interval between winter wheat crops to once every 3 or 4 years can lower jointed goatgrass seed density in soil as much as 70% to 90%. A second crucial step is to strengthen the winter wheat canopy using cultural practices (competitive cultivars, nitrogen or phosphorus placement, higher seeding rates)—a strategy that can reduce jointed goatgrass seed production 45% to 60%. Combining these tactics can reduce jointed goatgrass density in future wheat crops 90% to 95%.

In areas where planting alternative crops is not practical, cultural tactics that strengthen the winter wheat canopy remain effective in minimizing both wheat yield loss and seed production by jointed goatgrass. Lowering the density of jointed goatgrass also provides the added benefit of improving herbicide effectiveness.

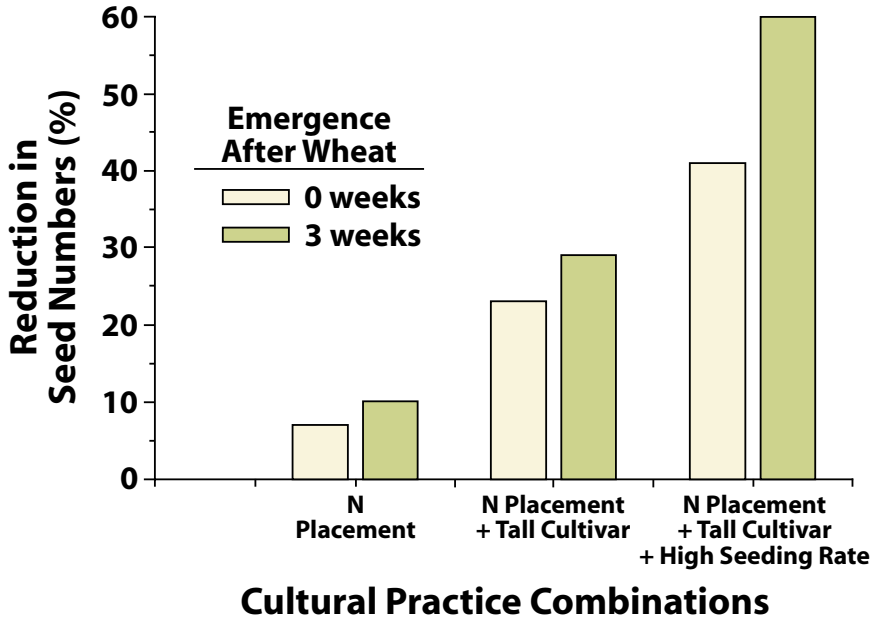
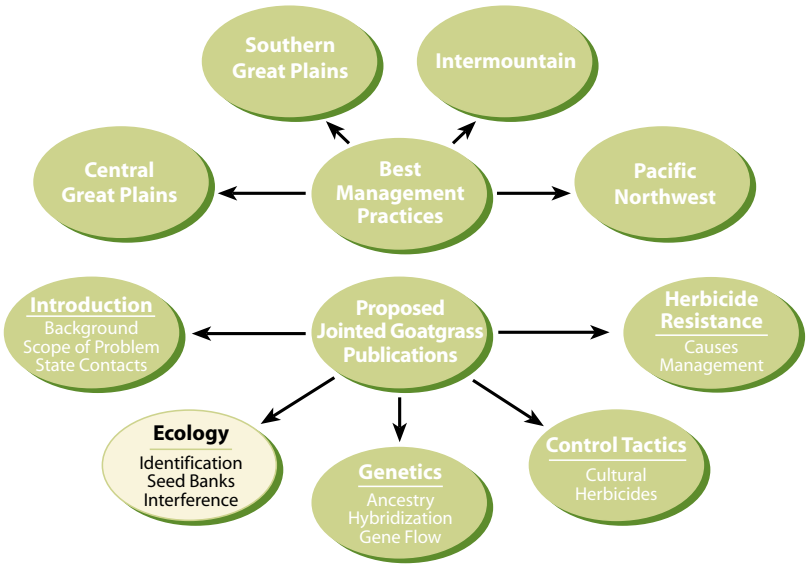


Figure 8. Seed production of jointed goatgrass as affected by combinations of cultural practices in winter wheat. Nitrogen was banded with wheat seeds at planting; high seeding rate was 65 pounds per acre compared with 40 pounds per acre.



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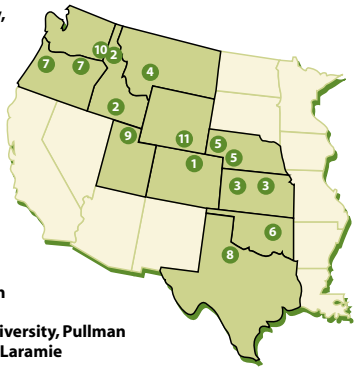

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