2009

MANAGING ANNUAL BROMES IN THE NORTHERN GREAT PLAINS

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Proceedings, The Range Beef Cow Symposium XXI
December 1, 2 and 3, 2009, Casper WY

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INTRODUCTION

Annual bromes periodically have substantial impact on rangelands in the northern Great Plains. The often rapid increases in annual brome populations and there negative effects on forage and animal production are justified cause for concern. However, population increases are predictable and management tools have been successfully identified for short-term control. Fort Keogh Livestock and Range Research Laboratory is examining new applications of established methods and testing whether careful timing and integration of control methods may be key to long-term reduction of annual bromes.

SPECIES IDENTIFICATION AND BASIC BIOLOGY

There are two prominent species of annual bromes in the Northern Plains, cheatgrass (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*). Japanese brome is typically more abundant than cheatgrass in Great Plains rangeland, whereas cheatgrass is more common in farmed or heavily disturbed sites and on shallow soils of south and west-facing slopes on rangeland. People often confuse the two species, but they are easily distinguished. Spikelets of cheatgrass tend to be narrow with long twisted awns and the inflorescence turns purple at maturity. Japanese brome spikelets are broader and have short, straight awns and the inflorescence goes from green to straw-colored at maturity. Good illustrations are available at the USDA Plants database (http://plants.usda.gov/).

Both species are similar in that being annuals, they depend on rapid growth and abundant seed production. Seed and vegetation production are both density-dependent (Young et al., 1969; Whisenant, 1990). So individuals will tend to produce more of each when there are fewer plants in close proximity and plants will be smaller with fewer seeds at high densities. Some seeds will germinate during spring, but germination is favored by wet conditions in fall and most seeds germinate the first or second fall after they are produced (Baskin and Baskin, 1981; Smith et al., 2008). The most productive years for brome will be those with wet springs following wet falls (Haferkamp et al. 2001 b).

Litter management is important because of its effects on soil moisture near the soil surface. Whisenant (1990) explained as much as 90% of the variation in Japanese brome density using previous fall precipitation and litter mass. He also noted a positive relationship between litter mass and brome seed production. Adding to this problem, the lower quality litter from annual bromes slows decomposition, which causes greater litter accumulation and increases brome seedling establishment (Ogle et al., 2003). Because of its dependence on both fall and spring conditions and the interaction with litter, brome production is erratic and may give the impression of a sudden and rapid invasion during favorable years.

COMPETITION

Early research indicated that Japanese brome competes with our dominant perennial grasses, such as western wheatgrass, but the tradeoff may lead to a net increase in production. Sites with an additional 690 lbs/ac of brome increased total grass production 365 lbs/ac (Haferkamp et al., 1997). While this may sound appealing from the standpoint of forage production, the net effect is a loss on two fronts because western wheatgrass produced 27% less with brome present and forage quality was reduced. Additionally, the increase in total biomass appears the exception rather than the rule. Haferkamp et al. (2001 b) and Vermeire et al. (2008) observed similar total production on sites with abundant brome and those with limited brome. In each case, brome simply replaced more desirable species. Brome impacts may be more severe belowground. Ogle et al. (2003) reported annual bromes reduced aboveground biomass 28% and reduced belowground biomass 40%. Cheatgrass, in particular, can reduce soil water content and increase water stress on neighboring native plants (Melgoza et al., 1990).

CHEMICAL CONTROL

Herbicides most commonly recommended for annual brome control are imazapic, glyphosate, and a combination of the two. Imazipic is a pre-emergent and post-emergent herbicide recommended for fall application. Glyphosate is often recommended for early spring application, when annual bromes are active and most desirable species are not growing. Imazapic has provided effective short-term control, but often injures perennial grasses and use of glyphosate requires careful timing for good brome control without damaging preferred plants.

We are examining the use of growth regulating herbicides that are commonly used to control broadleaf weeds to determine their effects on annual bromes. These auxinic herbicides, such as 2,4-D, dicamba, picloram, and aminopyralid have been shown to cause seed sterility in cereal crops if applied during development of reproductive structures. Initially we tested 2,4-D, dicamba, and picloram at typical field rates under greenhouse conditions (Rinella et al., In press) then repeated the study using picloram and aminopyralid in the field. Picloram caused nearly 100% sterility in the greenhouse and more than 95% sterility in the field when applied at internode, boot, or shortly after heading stages of growth (Table 1). Aminopyralid also reduced seed production more than 95%. Dicamba was slightly less effective and 2,4-D was not effective.

Table 1. Average percent germination of Japanese brome seed after plants were not treated or treated with three herbicide/rates at three growth stages.

Growth Stage	Herbicide Treatment			
	Control	Aminopyralid (half rate)	Aminopyralid (full rate)	Picloram
	------------------------------	% Germination	------------------------------	
Internode	61.0	0.0	1.4	0.4
Boot	65.0	0.1	4.7	0.0
Flowering	79.0	1.5	0.4	1.0

One concern was that with the rapid development typical of annual bromes, the period of vulnerability to herbicide would be short. Additionally, annual brome development is often not synchronized because of micro-environmental differences within a pasture (Young et al., 1969). However, since picloram and aminopyralid were effective across three development stages, they have potential for effective control at a large scale with a single application.

GRAZING MANAGEMENT

Grazing can affect annual bromes through consumption of seeds, consumption of leaves and reduction of litter. During early spring, annual bromes have high forage quality, but because they mature quickly, they may be only 2-4% crude protein most of the growing season. The exception is that seed heads of Japanese brome may have crude protein values of 8-13%. In fact, cattle will selectively graze annual bromes in early spring and select the spikelets later. Still, livestock performance has been improved by brome control. Haferkamp et al. (2001 a) increased steer daily gain by 0.25 lb following brome control with atrazine. Atrazine reduced annual bromes from 14 to 10% of the diets, but bromes comprised less than 10% of the biomass on treated pastures, indicating steers still selected brome. Some of the improvement in gains likely resulted from increased crude protein and production of the perennial grasses.

Greenhouse studies indicated frequent clipping of Japanese brome will reduce its total production 57% (Haferkamp et al., 1999). Our field studies also indicate grazing when seed heads are emerging can directly reduce seed availability. Intensive grazing in a single day during this period reduced germination from the soil seedbank 45%, meaning an even greater portion of the current year's crop had been removed. Grazing during mid-spring will provide the best livestock gains and reduce seed production. Logistically, having significant direct grazing impact over large areas may be difficult because of patchy grazing distribution or the difficulty of intensively grazing brome during the short window of opportunity. If grazing pressure is removed with adequate time and growing conditions, the bromes may tiller and still produce seed.

Grazing management can also have indirect effects on annual bromes through manipulation of litter. A 6-year study of seven grazing strategies indicated that pastures grazed after June 1 tended to have about 36% as much brome as those where grazing was completed before June (Vermeire et al., 2008; Figure 1). The difference was that winter and early spring pastures allowed little use of brome and stockpiled standing dead and litter during fall. This difference was significant because additional moisture held near the soil surface by litter can be the difference between suitable and unsuitable conditions for brome germination. Grazing strategies that allowed rest during the annual bromes' flowering period had intermediate levels of brome. Similarly, we have observed more annual brome in sites that are not grazed by livestock than those that are moderately grazed.

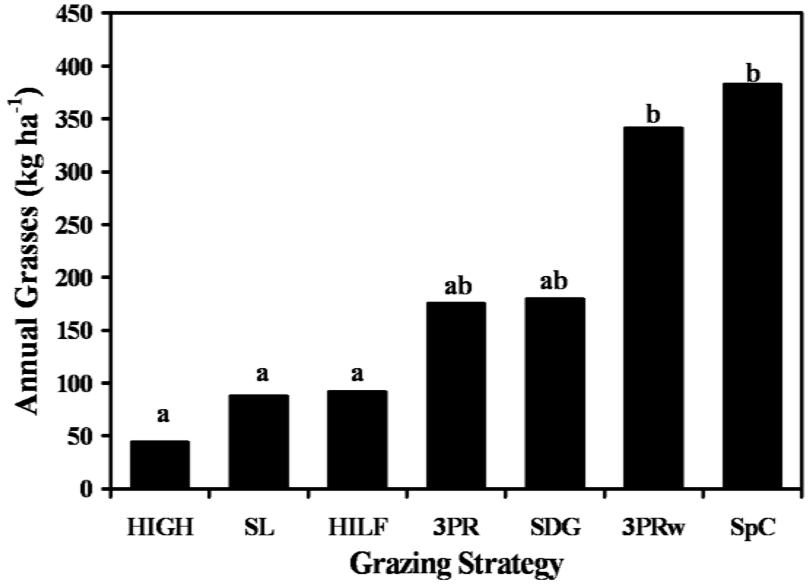

Figure 1. Annual grass standing crop following release from 6 years of 7 grazing strategies (Vermeire et al., 2008). Severe use (HIGH); 1-pasture, 1-herd, season-long (SL); 12-pasture, 1-herd, 24-day graze, 706-day rest, high-intensity low-frequency (HILF); 3-pasture, 1-herd, 15- and 30-day graze, twice-over summer rotation (3PR); 15-pasture, 1-herd, 3-day graze, 42-day rest, short-duration grazing (SDG); 3-pasture, 1-herd, winter rotation (3PRw); and 1-pasture, 1-herd, spring calving pasture (SpC)

FIRE MANAGEMENT

Fire is proving to be an effective brome management tool through its effects on litter removal and direct mortality on brome seeds and plants. Annual bromes have been reduced 68% following summer fire and were not affected in the short-term by moderate grazing the first growing season after fire. Others have observed reductions in brome biomass and density for 1-3 years following spring fire (Whisenant and Uresk, 1990) and assumed litter reduction to be a major factor. Under very dry or wet periods, litter has little effect on soil moisture, but it can improve moisture relations under moderately dry conditions and facilitate annual brome germination.

On-going studies evaluating effects of fire seasonality on brome-dominated sites indicate summer, fall and spring fire all reduced annual brome density. Controlled lab experiments determined that fuel loads common to the northern Great Plains are sufficient to reduce germinable seed on the soil surface by 98-100% (Vermeire and Rinella, 2009; Figure 2). On brome-dominated sites, fire in any season reduced brome density, but only 38% the first year. Seeds on the soil surface, in the litter, or in the plant canopy are very vulnerable to heat damage from fire. However, seeds buried in the soil are protected from fire. Whisenant (1990) observed immediate reduction in the litter seed bank following spring fire and a delayed reduction in the soil seedbank. Dry fall weather following fire likely helps to deplete the seedbank and extends treatment life, but effects of a single fire will be reduced under wet fall conditions allowing surviving seeds to germinate.

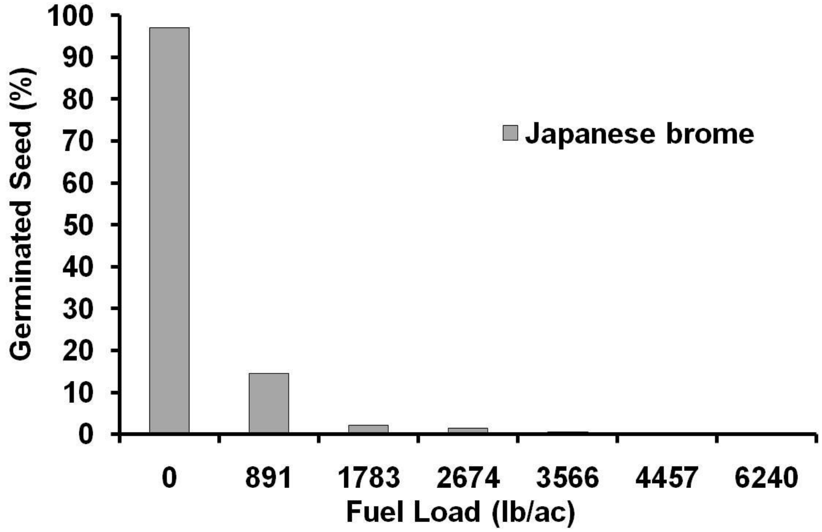

Figure 2. Percent germination from soil surface-deposited Japanese brome seed exposed to fire at six fuel loads and a non-burned control. From Vermeire and Rinella, 2009.

Although summer fire has generally had strong negative effects on annual bromes, we experienced one case where brome biomass was nearly double that on non-burned sites, spring- or fall-burned sites. Extremely wet conditions prevailed during late summer, fall and spring. Although summer fire reduced brome density, surviving plants were much larger. The weather events leading to this result were rare, but suggest interactions with fire and post-fire weather can be significant.

As important as the generally negative effects of fire are on brome, fire effects on other species have been encouraging. Native perennial cool-season grasses have generally increased about 60% following summer fire and western wheatgrass has typically doubled. Our seedbank work has indicated that fire in any season has reduced germinable seed of non-native forbs 88%, with no short-term effect on native perennial grasses and forbs.

CONCLUSIONS

Results to date indicate herbicide, grazing and fire are each effective tools in managing annual bromes. Ongoing research is investigating how the timing and integration of these management tools will affect the life span of control measures and how other species are affected. We expect that fire and grazing management can be followed by growth regulating herbicides to rapidly deplete the annual brome seedbank.

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