SWITCHGRASS AND BIG BLUESTEM RESPONSE TO SPRING BURNING AND GLYPHOSATE APPLICATION: HAY, BIOMASS, AND SEED YIELDS.

M.A. Sanderson, R.R. Schnabel, W.S. Curran, W.L. Stout, D. Genito, and B.F. Tracy[1]

Abstract

Cool-season weeds frequently invade stands of warm-season grasses, such as switchgrass (*Panicum virgatum* L.) and big bluestem (*Andropogon gerardii* Vitman) in the northeast USA. Spring burning or glyphosate [N-(phosphonomethyl) glycine] application may be useful in controlling cool-season weeds. Our objective was to determine when burning or glyphosate application in the spring affected forage or seed yield in switchgrass and big bluestem. We burned or applied glyphosate to switchgrass and big bluestem in mid-April, early-May, and late-May in 1998 and 1999 at Rock Springs, PA. Dry matter yield was measured in July (hay harvest) or September (bioenergy feedstock harvest). Switchgrass seed yield was measured in September. Burning in mid-May 1998 reduced hay yields of switchgrass and big bluestem by 40 to 44% compared with burning in mid-April. Glyphosate reduced yields of both warm-season grasses when applied later than mid-April. Applying glyphosate to switchgrass in late May reduced hay yields by 80% and biomass feedstock yields by 30%. Late application of glyphosate to big bluestem reduced hay yields by 90% and biomass feedstock yields by 40%. A late burn reduced yields less than a late application of glyphosate. Switchgrass seed yields were not affected by burning or glyphosate in 1998, whereas burning increased seed yields in 1999. Switchgrass and big bluestem can be burned any time through the first week of May in central Pennsylvania. Glyphosate application, however, should be done before mid April if switchgrass or big bluestem are to be cut for hay in summer or by the first of May if the grasses are to be harvested in September or later.

Introduction: Cool-season weeds often invade stands of warm-season grasses during early spring before the warm-season grasses are competitive. These weeds reduce both warm-season forage yield and stand life. Glyphosate can be used in early spring before green up of the warm-season grass to control cool-season grasses and broadleaf weeds. Burning the grass residue in spring may also control some weeds. Timing of these weed control techniques is critical to both control weeds and prevent damage to newly emerging warm-season grasses. Sometimes weeds may not be at the proper developmental stage for effective control with herbicides before the warm-season grass has greened up. Thus, waiting to apply a nonselective herbicide, such as glyphosate, or burning too late may damage the warm-season grass. Applying herbicide or burning too early may allow for subsequent weed emergence that can compete with the warm-season grasses.

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Perennial warm-season grasses, such as switchgrass and big bluestem, have multiple uses including livestock forage, soil conservation, and wildlife habitat. Switchgrass has also been studied extensively as a biomass energy crop (Sanderson et al., 1996). Early season weed control is critical in each of these uses. Our objective was to determine how timing of burning or glyphosate application in the spring affects forage, biomass, and seed yield of switchgrass and big bluestem.

Materials and Methods: The field experiment was conducted in 1998 and 1999 at the Russell E. Larson Agricultural Research Center near Rock Springs PA. Soil at the site is a Hagerstown silt loam (fine, mixed, semiactive, mesic Typic Hapludalfs). Soil tests indicated no need for lime, P, or K. Established (10 to 20 years old) plantings of three switchgrass cultivars (Pathfinder, Trailblazer, and NJ50) and two big bluestem cultivars (Pawnee and Niagara) were burned or treated with glyphosate at 1 lb a.i./ac on three dates each year. Plots were burned on 15 April, 6 May, and 22 May 1998. Glyphosate was applied on 21 April, 6 May, and 25 May 1998. In 1999, plots were burned on 28 April, 6 May, and 14 May. Glyphosate was applied on 28 April, 6 May, and 18 May. At the April treatment date, switchgrass and big bluestem were just greening up and had about 1 to 2 inches of visible growth. At the early May treatment date, both grasses were 5 to 7 inches tall and had about two fully expanded leaves. At the late May treatment date, both grasses were 10 to 14 inches tall and had three to four fully expanded leaves but had no elongated internodes.

There was one planting of each grass cultivar. Treatments were randomly assigned to two replicate plots (20 ft by 30 ft) within each grass cultivar. Thus, there were six plots total of each herbicide and burning treatment and six control (not burned or treated with herbicide) plots for switchgrass and four treated and control plots for big bluestem. In early April of each year, standing residue was clipped to a 4-inch stubble and removed from the plots designated for herbicide treatment. Standing residue and litter were left in place on the control plots, whereas most above ground residue was removed by fire in the burned treatments. A second set of plots not used in 1998 was used for treatments in 1999.

The plots were split in half and one half harvested in July and the other half harvested in September. The July harvest simulated the use for hay (harvest at the late boot to early head stage), whereas the September harvest simulated the use for bioenergy feedstock (harvested after seed maturation). At each harvest, four 2 ft by 2 ft quadrats were cut to a 6-inch stubble by hand. Each quadrat sample was bagged separately and dried at 135 ^{o}F for 48 h to determine dry matter yield. In September of each year, the panicles in each quadrat were removed and threshed to determine seed yield for switchgrass only. Panicles were threshed by hand and the seed cleaned by hand- rubbing and separation in an air-column seed blower. Seeds were air dried and seed yield (total caryopsis weight) per unit area was calculated. Weeds are not problematic in this study, so no weed control data were collected.

The design of the experiment was a randomized complete block. Data were analyzed separately for each grass species, year, and harvest within years. The individual grass cultivars were not replicated, thus the cultivars were treated as blocks with two replicate plots nested within each block. Comparisons of treatment means included 1) control vs the average of burning and glyphosate treatments, 2) early vs late burn, 3) early vs late glyphostate, and 4) late burn vs late glyphosate.

Results and Discussion: In 1998, switchgrass hay yields were reduced by both burning and glyphosate when applied in May (Table 1). A late application of glyphosate, however, reduced switchgrass hay yields by 77% compared with the April application date, whereas a late burn reduced switchgrass hay yields by 44% when compared with early burning. Switchgrass harvested in September to simulate a biomass feedstock harvest was not affected by the date of burning; however, a late May glyphosate application reduced biomass yields by 35% compared with a mid-April treatment. A similar pattern of responses was observed in big bluestem (Table 2). Late burning reduced hay yields in big bluestem by 40% compared with a mid-April burn, whereas late glyphosate application reduced hay yields by 84% and biomass feedstock yields by 48% compared with a mid-April treatment.

Switchgrass hay or biomass yields were not affected by the date of burning in 1999 (Table 1). Similar to 1998, however, a late glyphosate application reduced hay yields by 80% and biomass feedstock yields by 29% compared with the mid-April treatment. In 1999, big bluestem hay yields were not affected by burning, whereas glyphosate application reduced hay yields by 26 to 91% and biomass feedstock yields by 41% (Table 2). Biomass feedstock yields of big bluestem, however, increased by 80% with later burning. Mitchell et al. (1994) reported that a mid-spring (late April) burn increased big bluestem forage yield on native tallgrass prairie by 18 to 36% compared with an early spring (March 31) burn and increased yields by 52% compared to not burning. Burning young (5 year) stands of switchgrass and big bluestem, however, reduced yields compared to unburned plots during 3 yr in Nebraska (Cuomo et al., 1996). Delayed burning from mid-March to mid-May progressively decreased yields of both grasses. Burning in mid-May reduced yields by half compared to unburned plots each year. Burning in consecutive years reduced yields.

Seed yields of switchgrass were not statistically different among treatments in 1998 (Table 3). Burning increased switchgrass seed yields in 1999 compared to the glyphosate and control treatments. Later burning treatments increased seed yields in 1999, whereas later glyphosate treatments reduced seed yields.

Although weed control was not a component of this study, previous research indicates that cool-season weed control generally increases as application is delayed in the spring. Therefore, timing of glyphosate for effective control of cool-season weeds while maintaining warm-season grass tolerance may be a difficult compromise. Both weed and grass stage of development should be assessed before glyphosate application to help determine the effect of spring application.

Conclusions: Generally, the timing of burning treatments did not have a large effect on hay or biomass yields of switchgrass and big bluestem. When yields were affected, the late burning treatment did not reduce yields as much as a late application of glyphosate. Delaying glyphosate application into May frequently reduced warm-season grass yields. Thus, mid April seems to be the threshold date for glyphosate application to switchgrass and big bluestem sods in climates similar to central Pennsylvania. Frequently, the herbicide effect on hay yields persisted into the later biomass harvest; however, burning effects on yield were most evident in the first (hay) harvest. Thus, burning or glyphosate application may be more flexible for warm-season grasses managed for a single late-season harvest, such as for biomass energy feedstock production.

Literature Cited:

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Table 1. Yields of switchgrass burned or treated with glyphosate during 1998 and 1999 at Rock Springs, PA.

	1998		1999	
Treatment	July	September	July	September
Burned	----------------Dry matter, lb/ac----------------------			
Mid-April	5144	8678	2484	4659
Early May	4226	8337	2253	4956
Late May	2864	7107	2357	5171
Glyphosate				
Mid-April	5087	8463	2889	5172
Early May	3514	8383	2724	4703
Late May	1180	5498	565	3651
Control	4562	8124	1951	3283
Standard error	375	975	253	570
Contrasts[a]				
Control vs. other treatments	**	NS	NS	**
Early vs. late burn	**	NS	NS	NS
Early vs. late glyphosate	**	**	**	*
Late burn vs. late glyphosate	**	NS	**	*

[a]* and ** indicate significantly different treatment means at the 0.05 or 0.01 probability level, respectively. NS, not significant.

Table 2. Yields of big bluestem burned or treated with glyphosate during 1998 and 1999 at Rock Springs, PA.

	1998		1999	
Treatment	July	September	July	September
Burned	----------------------Dry matter, lb/ac-------------			
Mid-April	4394	6862	2284	3002
Early May	4340	5838	2277	3797
Late May	2644	6087	2245	5380
Glyphosate				
Mid-April	4470	6175	3192	3825
Early May	2824	6031	2376	3711
Late May	727	3180	291	2241
Control	4916	5850	2162	3115
Standard error	622	591	572	599
Contrasts[a]				
Control vs. other treatments	**	NS	NS	NS
Early vs. late burn	**	NS	NS	**
Early vs. late glyphosate	**	**	**	**
Late burn vs. late glyphosate	**	**	**	**

[a]** indicates significantly different treatment means at the 0.01 probability level. NS, not significant.

Table 3. Seed yields of switchgrass burned or treated with glyphosate during 1998 and 1999 at Rock Springs, PA.

Treatment	1998	1999
	---------Seed, lb/ac------	
Burned		
Mid-April	406	64
Early May	501	195
Late May	376	268
Glyphosate		
Mid-April	423	175
Early May	458	148
Late May	347	100
Control	488	76
Standard error	136	31
Contrasts[a]		
Control vs. other treatments	NS	**
Early vs. late burn	NS	**
Early vs. late glyphosate	NS	*
Late burn vs. late glyphosate	NS	**

[a]** indicates significantly different treatment means at the 0.01 probability level. NS, not significant.

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