FORAGE ENHANCEMENT OF BROOMSEDGE

(*Andropogon virginicus*) INFESTED

PASTURES

By

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INTRODUCTION

Chapters II, III, and IV of this thesis are to be submitted for publication in the Journal of Production Agriculture, published by: American Society of Agronomy, Crop Science of America, and Soil Science of America.

CHAPTER I

LITERATURE REVIEW

Literature Review

BACKGROUND

Broomsedge (*Andropogon virginicus* L.) is a native, warm-season, short-lived perennial bunchgrass growing on millions of acres of pastureland in the southeastern United States. Broomsedge has an average life span of 3 to 5 yr. Work in Tennessee found that half of transplanted seedlings died at the end of 3 yr and all plants were gone in 7 yr in the absence of competition (Neel, 1936). Rice (1972) reported that broomsedge produced allelopathic chemicals that inhibited other plants as well as nitrogen-fixing bacteria.

BROOMSEDGE QUALITY

Nutritive value of broomsedge declines in late June to early July. In one experiment, crude protein (CP) decreased from 11.2% on June 10 to 7.8% on July 10, and was only 5.9% by September 11 (Dustman and Van Landingham, 1930). Thurman (1969) reported *in vivo* dry matter digestibility of broomsedge decreased from 58.1% when cut at a 6-in. height to 43.2% when cut at a 24-in. height. Terry and Tanner (1986) reported that broomsedge nutritive value peaked in mid-April, was lowest in July, and recovered in the fall. They found *in vitro* organic matter disappearance (IVOMD) levels of 52% in mid-April and 23% in February; CP peaked at 8.0% in mid-April and declined to 3.5% in late July.

SOIL FERTILITY OF BROOMSEDGE PASTURES

Broomsedge often occurs in nearly pure stands and has been reported to occur mostly in old fields with low soil fertility. Broomsedge has a low requirement for phosphorous (P); thus, it is better able to survive than other species on low P soils (Peters and Lowance, 1974). Thurman (1969) reported good forage response of broomsedge to nitrogen (N), but there was no forage response to P and potassium (K) without N. However, the addition of 60 lb/acre of P_2O_5 and K_2O with 120 lb/acre N increased yields by 200 to 500 lb/acre compared to 120 lb/acre N alone, but this response was not enough to be of value to livestock producers.

GRAZING OF BROOMSEDGE

Broomsedge is generally recognized as an unpalatable weed that produces forage that is low in nutritive value for cattle (Griffin et al., 1988). Cattle will eat broomsedge, however, when it is young and tender. Peters and Lowance, (1974) reported that lightly grazed pastures had a solid stand of broomsedge, but broomsedge was absent on adjacent heavily grazed pastures. Neel (1936) and Klingman (1971) reported that cattle grazed broomsedge more readily when fertilized, and close grazing reduced broomsedge vigor. Klingman also stated that mowing was required to keep broomsedge in a palatable condition.

BURNING BROOMSEDGE INFESTED PASTURES

Burning can improve forage nutritive value of tallgrass prairie by removing standing dead material, which can increase stocker gains by 10 to 20% (Bernardo et al., 1988). Burning also allows soil to trap solar radiation and causes vegetation to green up 2 to 3 weeks earlier in the season. Pinkerton and Rice (1992) reported that 'Coastal', 'Brazos', 'Tifton 44', and common bermudagrass [*Cynodon dactylon* (L.) Pers.] were not affected by either headfire or backfire. 'Tifton 78' was damaged by backfire, but not headfire. However, this effect had disappeared by the third harvest in the same yr. Thurman (1969) reported very little effect of spring burning on broomsedge production. Burning in spring reduced yield of broomsedge 200 lb/acre below a mowing treatment the first yr. By the second and third yr of the experiment, however, there were no differences in forage production of broomsedge between the two treatments.

There has been little work done on the effects of late-season burning on broomsedge. Broomsedge has a similar growth form to little bluestem [*Schizachyrium scoparium* (Michx.) Nash]. Due to little bluestem's caespitose growth habit, buds are susceptible to late season burns (Engle et al., 1993). Ewing and Engle (1988) reported burning in September reduced the vigor of little bluestem. Since broomsedge and little bluestem have similar growth habits, broomsedge vigor might also be reduced by late season burns.

ESTABLISHMENT OF COOL-SEASON FORAGES ONTO BROOMSEDGE INFESTED PASTURES

Overseeding of cool-season forages into perennial warm-season pastures can extend grazing season, increase forage yield, improve forage nutritive value, and improve cattle performance. Clovers can also reduce N inputs by fixing atmospheric N. Evers (1985) reported 115 lb/acre N was required to equal the N accumulation of dry matter provided by 'Yuchi' arrowleaf clover (*Trifolium vesiculosum* Savi). In addition to providing forage, Evers (1983) concluded that annual cool-season clovers in perennial warm-season pastures were as effective as simazine for control of spring weeds since they compete with weeds for light, space, and moisture.

Establishment of cool-season forages can vary from planting into a conventionally tilled seedbed to broadcast seeding onto permanent pastures with little or no seedbed preparation. Several grass herbicides have been used to suppress warm-season grass growth and favor cool-season growth. Grichar et al. (1988) reported that sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one}, quizalofop {(+)-2-[4[(6-chloro-2-quinoxalinyl)oxy]phenoxy]propanoic acid}, fluazifop {(R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid}, and haloxyfop {2-[4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid} resulted in less than 50% desiccation when applied in the fall of 1987 with cool weather conditions, and greater than 80% desiccation in the fall of 1985 and 1986 with warmer conditions. They also reported that desiccation was slow ranging from 29 to 56 days after treatment (DAT), and that fluazifop at 0.47 lb active ingredient (ai)/acre significantly reduced bermudagrass recovery by the following spring. Fribourg et al. (1978) reported that paraquat 1,1'-dimethyl-4,4'-bipyridinium ion caused rapid leaf burn within 2 to 3 days, and that paraquat at 0.5 lb ai/acre severely reduced tall fescue when applied in the fall to suppress growth for establishing clovers. They suggested that paraquat could be substituted for disking in a pasture renovation program. Overseeding into ashes after a prescribed burn makes an adequate seedbed preparation for small-seeded plant species such as clovers (Vallentine, 1989).

Evers (1995) evaluated four planting methods on areas mowed at 1-in. height to determine their effects on seedling density and DM production of rose clover. Lowest seedling density and yield of rose clover resulted with broadcasting seed onto the undisturbed sod. There was no difference in establishment and production among other three treatments: 1) no-till drill, 2) no-till drill plus desiccation with 0.12 lb ai/acre sethoxydim , and 3) light disking, broadcasting seed, and then dragging with a harrow. Fribourg et al. (1978) concluded that the success of establishing clovers into sod depends more on weather conditions than seedbed preparation, and they found little difference among planting method for clover establishment for disking, spraying paraquat 0.5 lb ai/acre in bands, spraying paraquat 0.25 lb ai/acre broadcast, and spraying glyphosate 1.5 lb ai/acre in bands. Paraquat broadcast at 0.5 lb ai/acre, however, generally resulted in better clover establishment. Tillage in the fall should not damage bermudagrass based on Mooso et al. (1990) findings. They reported that two light diskings (1-in. deep) in bermudagrass pastures in the fall for clover production had no effect on bermudagrass hay production the next yr.

HERBICIDES FOR BROOMSEDGE CONTROL

Chemicals reported to control broomsedge are paraquat, glyphosate {N-(phosphonomethyl)glycine}, MSMA {monosodium salt of methane arsonate}, bromacil {5-bromo-6-methyl-3-(1-methylpropyl)-2,4(1H,3H)pyrimidinedione}, diuron {N'-(3,4-dichlorophenyl)-N,N-dimethylurea}, and tebuthiuron {N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]N,N'-dimethylurea}. Vaught et al. (1977) reported that 0.5 lb ai/acre of paraquat reduced broomsedge standing crop from 10 to 45% when applied from May to

September. Albert (1965) reported that paraquat burned back bermudagrass, but bermudagrass promptly regrew without any noticeable injury from the paraquat. Vaught et al. (1977) also reported that 0.5 lb ai/acre of glyphosate applied from May to September reduced broomsedge standing crop by 70-80%, while 1.0 and 2.0 lb ai/acre rates resulted in over 90% control except when applied early May. Johnson and Ware (1978) reported that bermudagrass was injured by glyphosate when evaluated 3 weeks after treatment (WAT), but fully recovered 6 WAT from 0.34 lb ai/acre and 9 WAT from 0.67 lb ai/acre. Bryson and Wills (1985) reported that 1.25 lb ai/acre glyphosate reduced standing crop of bermudagrass by 22% when evaluated 13 WAT. Lowance et al. (1975) reported 90% control of broomsedge with 5.0 lb/acre of MSMA with little to no effect on smooth bromegrass (*Bromus inermis* Leyss). Griffin et al., (1988) reported that 5.0 lb ai/acre bromacil reduced broomsedge by 100%, but also reduced bermudagrass, bahiagrass (*Paspalum notatum* Flugge), and dallisgrass (*P. dilatatum* Poir) by 92, 85, 38%, respectively. They also reported that 7.5 lb ai/acre diuron and 5.0 lb ai/acre tebuthiuron reduced broomsedge by 94%, but also reduced bermudagrass, bahiagrass, and dallisgrass by 53, 81, and 43%, respectively.

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CHAPTER II

FORAGE ENHANCEMENT OF BROOMSEDGE INFESTED PASTURES WITH SPRING MANAGEMENT PRACTICES

Forage Enhancement of Broomsedge Infested Pastures

with Spring Management Practices

T.J. Butler, L.A. Redmon, J.F. Stritzke,* C.L. Goad, G.W. Cuperus, J.D. Enis

Broomsedge (*Andropogon virginicus* L.) is generally considered to be low in nutritive value for cattle. Experiments were initiated on six sites in southeastern Oklahoma in spring of 1995 to determine cultural effects on broomsedge. A split-plot design with a spring burn and no burn as main plots and fertility subplots of no fertility, 100 or 200 lb/A N with P_2O_5 and K_2O applied according to soil test recommendation. Broomsedge density was not affected by N rate the first yr, but was reduced by both N rates the second yr. Forage yields were taken in the second yr and total DM production and crude protein (CP) increased as N increased, however, broomsedge production did not increase. There was no difference in CP between broomsedge and bermudagrass components at the no fertility and 100 N level. Spring burning had little effect on broomsedge density or broomsedge production. Burning for 2 yr did, however, effect total DM production at one site

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where bermudagrass was released. Spring burning followed by one-time spring disking reduced broomsedge density and increased bermudagrass DM production.

Broomsedge is a native, warm-season, short-lived perennial bunchgrass growing on millions of acres of pastureland in the southeastern United States. Nutritive value of broomsedge declines in late June to early July. In one experiment, crude protein (CP) decreased from 11.2% on June 10 to 7.8% on July 10, and was only 5.9% by September 11 (Dustman and Van Landingham, 1930). Thurman (1969) reported that the *in vivo* dry matter digestibility of broomsedge decreased from 58.1% when cut at a 6 in. height to 43.2% when cut at a 24 in. height. Broomsedge often occurs in nearly pure stands and has been reported to occur mostly in old fields with low soil fertility (Peters and Lowance, 1974). Broomsedge is generally recognized as an unpalatable weed that has low forage nutritive value for cattle (Griffin et al., 1988). Cattle will eat broomsedge, however, when it is young and tender. It has been observed that lightly grazed pastures had a solid stand of broomsedge, but broomsedge was absent on heavily grazed pastures (Peters and Lowance, 1974). Burning has been an accepted management tool for both native and introduced species, and has been recommended for insect control and cool-season weed suppression in bermudagrass (Pinkerton and Rice, 1992). Burning also allows soil to trap solar radiation and causes vegetation to green-up 2 to 3 weeks earlier in the season. Burning can improve forage nutritive value and palatability by removing standing dead material, which can also increase stocker gains by 10 to 20% (Bernardo et al., 1988). The purpose of this experiment was to determine the effectiveness of spring applied fertility, burning, and disking treatments on forage enhancement of broomsedge infested pastures.

MATERIALS AND METHODS

Six locations were selected in southeastern Oklahoma in the spring of 1995 that were infested with broomsedge. Soil samples were taken and broomsedge infestations were determined for all sites in the spring of 1995 before treatments were applied. Broomsedge density was determined by counting broomsedge plants in four 18- by 36-in. permanent quadrats. Nutrient status of soil samples from all sites was determined by the Soil, Water, and Forage Analytical Laboratory at Oklahoma State University and are listed in Appendix A.

At the Atoka, Durant, and Hartshorne sites, two replications of a split-plot design experiment with a spring burn and no burn as main plots and fertility as subplots was initiated in April 1995. Fertility subplot treatments included: 1) no fertility, 2) 100 lb/acre nitrogen (N) and P_2O_5 and K_2O according to soil test (Appendix A), 3) 200 lb/acre N and P_2O_5 and K_2O according to soil test recommendation; and 4) a one-time disk in late spring of 1995 was added to the burn mainplot plus 100 lb/acre N and P_2O_5 and K_2O according to soil test. At the other three sites (Ada, Antlers, and Hugo) burning and disking were not variables, so the same fertility treatments used above were applied with four replications in April 1995. Plant counts using four 18- by 36-in. quadrats per plot were taken on all six sites in August 1995 to determine effects of treatments on plant density.

In 1996, the entire experimental area at all six sites was burned to remove old standing material and fenced so forage dry matter (DM) yields could be determined. Nitrogen was reapplied to the 100 lb/acre and 200 lb/acre treatments in May 1996. At all locations except the Hugo site, forage yields were estimated in June 1996 by hand clipping two 18- by 36-in. quadrats in each plot. Forage yields could not be determined at the Hugo site since cattle broke into the fenced areas. Forage species components were estimated at time of clipping and used to calculate forage production of the various species. Harvested forage was oven-dried (118°F) to a constant moisture and weighed. A portion of the harvested forage sample from each plot plus the hand separated broomsedge and bermudagrass components from the remainder of the sample were then sent to the Soil, Water, and Forage Analytical Laboratory to determine CP. Total N was determined by using the "Leco N determinator" dry combustion unit (Sweeney and Rexroad, 1987). In August 1996, elongated broomsedge stems were counted in four 18- by 36-in. permanent quadrats to estimate the vigor of broomsedge plants. Data was analyzed using SAS® procedures (SAS Institute, 1996) and ANOVA procedures were performed and treatment means were separated using a Fisher's protected LSD at the 0.05 level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

All six sites were deficient in P with indices ranging from 3.5 to 9.5 parts per million (ppm) or 7 to 19 lb/acre (Appendix A) which was correlated with 60 to 80% sufficiency. This supports Peters and Lowance (1974) findings that broomsedge can thrive on soils low in P. Nitrogen was also deficient at all six locations with values ranging from 1 to 5 lb/acre. Potassium was deficient at four of the six locations with indices ranging from 151 to 421 lb/acre.

Spring burning had no effect on broomsedge plant density the first yr when broomsedge was growing in competition with other grasses (Table 1). Burning for 2 consecutive yr increased broomsedge stem density ($P<0.05$), but did not affect broomsedge DM production ($P>0.10$) (Table 2) which agrees with what Thurman (1969) found. Thurman reported that burning in spring only reduced yield of broomsedge by 200 lb/acre the first yr when compared to a mowing treatment, and there was no effect on forage production of broomsedge in the second and the third yr of the experiment. Burning for consecutive 2 yr did not affect total DM production at two of three sites. At the Atoka site there was an increase in total DM production with two consecutive burnings and this attributed to the increase in bermudagrass production when N was applied (Table 2).

Spring applied N had little effect ($P>0.10$) on broomsedge plant density in August 1995 (Table 1). Broomsedge stem density, however, was reduced ($P<0.001$) by August 1996 after two annual applications of 100 and 200 lb/acre N (Table 1). This was attributed to the increased competition from other grass species when N was applied for 2 yr. The 200 N rate reduced broomsedge stems ($P<0.10$) when compared to the 100 N rate in the second yr.

There was an increase ($P<0.001$) in total DM production (Table 2) with both N rates at the five harvested sites. The 200 N rate increased total DM production over the 100 N treatment only at the Atoka site (Table 2). This was attributed to increased bermudagrass DM production in the 200 N treatment. Broomsedge DM production was only increased with added N at the Antlers site (Table 2). Evidently, broomsedge was not able to compete with other grass species in the higher fertility environment. DM production of bermudagrass increased when fertilized with 200 N for 2 consecutive yr at four of the five sites (Table 2). At the Durant site, bermudagrass increased 710 lb/acre with 200 N when compared to the 0 N rate; however, due to variation of bermudagrass stand at this site this difference was not significant.

Crude protein of total forage increased ($P<0.001$) with both levels of added N at the five harvested sites. The 200 N rate increased CP ($P<0.05$) over the 100 N rate. Crude protein at the 0 N level averaged 7.7%, while CP at 100 N averaged 13.2%, and CP at 200 N averaged 15.9%. There was no difference in CP ($P>0.10$) between broomsedge and bermudagrass components at the 0 N and 100 N levels. Crude protein on June 28, 1996 averaged 7.5% for broomsedge and 8% for bermudagrass at the 0 N level. With 100 N, CP of broomsedge ranged from 10.7 to 11.4% and bermudagrass ranged from 11.2 to 13.0%.

The one-time disk in late May to early June destroyed the established broomsedge plants. Broomsedge seedlings emerged after disking, but were not competitive with other plants at the 100 N fertility level. Plant density in August 1995 for Atoka, Durant, and Hartshorne averaged 0.5 broomsedge plants/sq ft in the disk plus 100 N treatment, compared to 1.2 plants/sq ft in the 100 N alone treatment and 1.1 plants/sq ft in the no fertility treatment ($P<0.05$). When harvested on June 28, 1996, total DM production averaged over three sites was only 3060 lb/acre at the 100 N level compared to 4070 lb/acre when disked after 100 N. Much of this increase was attributed to bermudagrass since production of bermudagrass increased from 480 lb/acre at the 100 N to 1530 lb/acre in the disk plus 100 N treatment. Broomsedge production averaged 1460 lb/acre at the 100 N level compared to 810 lb/acre in the disk plus 100 N treatment. By August 1996, the one-time disk plus 100 N averaged 1.2 stems/sq ft, while the 100 N alone treatment averaged 3.1 stems/sq ft ($P<0.05$) and the no fertility treatment averaged 5.5 stems/sq ft (Table 1).

Observations at the Hugo site, where cattle broke into the plot area and grazed the area to ground level supports Neel's (1936) and Klingman's (1971) observations that close grazing of broomsedge reduces its vigor. The plot area was burned in early May 1996 to remove old standing material while an adjacent fenced area was not burned. The cattle had grazed the burned area to a height of less than 1 in., when observed on June 28, 1996, while essentially not grazing the broomsedge that had not been burned. End of season standing crop was taken in December from the burned and unburned areas. Forage production of broomsedge was only 1900 lb/acre in areas burned and grazed while yields in areas not burned and subjected to grazing averaged 5300 lb/acre.

SUMMARY

If bermudagrass is present in broomsedge infested pastures then burning, disking, and proper fertility could be integrated for utilization by cattle. Disking favors rhizomatous species such as bermudagrass, while having adverse affects on bunchgrasses. Adding 100 lb/acre N was similar to 200 N for improving nutritive value, increasing total DM production, and altering the competitive balance favoring desirable species on these low fertility broomsedge infested pastures. Burning can improve utilization and cattle performance by removing old growth and increasing forage intake. Burning results in 2 to 3 weeks earlier green-up of forages in the spring and can also favor rhizomatous species.

Proper fertility and utilization may decrease broomsedge competitiveness and persistence when bermudagrass is present. If no bermudagrass or other desirable grass species is present and the objective is to utilize broomsedge and other species that are present and do not respond to fertility, then old growth should be removed by burning or mowing and then double stock these areas and graze early in the spring for maximum benefit. If no desirable species are present and the objective is to increase productiveness, then the renovation process should include establishment of adapted species in conjunction with proper fertility, burning and tillage; then utilize proper grazing management for optimum production and utilization.

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Table 1. Average broomsedge density in August 1995 and 1996 for main plots of burn and no burn and fertility subplots levels of no fertility, 100 and 200 lb/acre N at Atoka, Durant, Hartshorne, Ada, Antlers, and Hugo sites.

Treatment	1995 Broomsedge plants	1996 Broomsedge stems
	no./sq ft	
Atoka, Durant, and Hartshorne sites†		
Main plots		
Burn	1.7 a‡	4.2 a
No Burn	1.0 a	2.5 b
Subplots		
No fertility	1.1 a	5.5 a
100 lb/acre N	1.2 a	3.1 b
Disk+100 lb/acre N	0.5 b	1.2 c
200 lb/acre N	0.9 ab	1.5 c
Ada, Antlers, and Hugo§		
No fertility	2.2 a	6.7 a
100 lb/acre N	1.6 a	3.2 b
200 lb/acre N	1.9 a	2.2 b

† 1996 main plots are burn for 2 yr and burn 1 yr, while subplots are fertility for 2 consecutive yr.

‡ Means for main plots or subplots within site grouping and yr followed by same letter do not differ ($P<0.10$).

§ Ada, Antlers, and Hugo sites were not burned in 1995 and all were burned in 1996.

Table 2. Average forage production of broomsedge, bermudagrass, other forage, and total forage production on June 28, 1996 for main plots of burn and no burn and subplots of no fertility, 100 N and 200 lb/acre N at Atoka, Durant, Hartshorne, Ada, and Antlers sites.

Treatment‡	Broomsedge	Bermudagrass	Other forage	Total forage
	lb/acre			
Atoka site				
Main plot				
Burn twice	1160 a†	1470 a	720 a	3350 a
Burn once	1130 a	560 a	590 a	2280 b
Subplot				
No fertility	1160 a	20 b	330 a	1510 c
100 lb/acre N	1350 a	510 b	910 a	2770 b
Disk + 100 N	1010 a	2640 a	1330 a	4980 a
200 lb/acre N	910 a	2510 a	760 a	4180 a
Durant site				
Main plot				
Burn twice	1890 a	350 a	550 a	2790 a
Burn once	1800 a	830 a	700 a	3330 a
Subplot				
No fertility	1840 a	150 a	80 b	2070 b
100 lb/acre N	1930 a	760 a	660 ab	3350 a
Disk + 100 N	1010 a	1270 a	600 ab	2880 ab
200 lb/acre N	1770 a	860 a	1130 a	3760 a
Hartshorne site				
Main plot				
Burn twice	1060 a	200 a	1620 a	2880 b
Burn once	660 a	460 a	1680 a	2800 b
Subplot				
No fertility	1120 a	40 b	620 b	1780 c
100 lb/acre N	1090 a	170 ab	1790 ab	3050 b
Disk + 100 N	420 a	670 a	3270 a	4360 a
200 lb/acre N	370 a	780 a	2550 a	3700 a
Ada site				
No fertility	340 a	240 b	420 a	1000 b
100 lb/acre	150 a	1090 a	1310 a	2550 a
200 lb/acre	310 a	1370 a	720 a	2400 a
Antlers site				
No fertility	1240 b	180 b	130 a	1550 b
100 lb/acre	2060 ab	2450 a	430 a	4940 a
200 lb/acre	2760 a	2260 a	140 a	5160 a

† Means for main plots and subplots for locations within columns followed by same letter do not differ ($P<0.05$).

‡ Ada and Antlers were not burned or disked.

CHAPTER III

FORAGE ENHANCEMENT OF BROOMSEDGE INFESTED PASTURES WITH OVERSEEDING OF RYEGRASS AND CLOVERS

Forage Enhancement of Broomsedge Infested Pastures with Overseeding of Ryegrass and Clovers

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Broomsedge (*Andropogon virginicus* L.) is generally considered to have low grazing value for cattle. Experiments were initiated on six sites in southeastern Oklahoma to determine the effects of three seedbed preparations for clovers and ryegrass establishment and production. In yr 1, a split-plot design with three main plots of mow in late summer, paraquat plus burn in late summer, and burn after frost and six subplots: no overseeding, overseeding ryegrass (Marshall and TAM90) and clovers (Yuchi arrowleaf, Overton R18 rose, ladino white). Dry conditions in the fall and spring resulted in no emergence of ryegrass and variable clover emergence and production. In late summer and fall of yr 2, main plot treatments were reapplied. Subplot treatments were modified to: no overseeding and a factorial arrangement of tillage and no tillage with overseedings of a clover mix and ryegrass. Paraquat plus burn and burn after frost seedbed preparations improved density of clover when compared to the mow treatment. Clover production was

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highest in paraquat plus burn treatment and generally lowest in burn after frost treatment. Tillage improved clover density and production at two of the five sites in the mow treatment, but did not improve clover density or production in the paraquat plus burn and in burn after frost treatments. Ryegrass emergence was generally highest in paraquat plus burn and burn after frost treatments. Tillage improved ryegrass emergence at three of the six sites in the mow, paraquat plus burn, and burn after frost treatments, however, there was no increase in ryegrass production associated with the increased plant density.

Broomsedge (*Andropogon virginicus* L.) is a native, warm-season, short-lived perennial bunchgrass growing on millions of acres of pastureland in the southeastern United States. Terry and Tanner (1986) reported that broomsedge nutritive value peaked in mid-April, was lowest in July, and recovered in the fall. They found *in vitro* organic matter disappearance (IVOMD) levels of 52% in mid-April and 23% in February; CP peaked at 8.0% in mid-April and declined to 3.5% in late July.

Renovation of broomsedge infested pastures by overseeding cool-season forages such as annual ryegrass or clover would be a good way to extend the grazing season, increase forage yield, improve forage nutritive value, and improve cattle performance. Establishment of cool-season forages can vary from planting into a conventionally tilled seedbed to broadcast seeding onto permanent pastures with minimal or no seedbed preparation. Fribourg et al. (1978) reported that paraquat caused rapid leaf burn within 2 to 3 days after treatment (DAT). Vaught et al. (1977) reported that 0.5 lb active ingredient (ai)/acre of paraquat reduced broomsedge standing crop by 10 to 45% when applied from May to September. Albert (1965) reported that paraquat desiccated bermudagrass, but bermudagrass promptly regrew without any noticeable injury from the paraquat. Mooso et al. (1990) reported that two light diskings (1 in. deep) in bermudagrass pastures in the fall for clover establishment had no effect on bermudagrass hay production the next yr. Overseeding into ashes after a prescribed burn makes an adequate seedbed preparation for small seeded plant species such as clovers (Vallentine, 1989).

Evers (1995) evaluated four planting methods on areas mowed at 1-in. height to determine their effects on seedling density and DM production of rose clover. Lowest seedling density and yield of rose clover resulted with broadcasting seed onto the undisturbed sod. There was no difference in establishment and production among other three treatments: 1) no-till drill, 2) no-till drill plus desiccation with 0.12 lb ai/acre sethoxydim , and 3) light disking, broadcasting seed, and then dragging with a harrow. The purpose of this experiment was to determine the effectiveness of overseeding ryegrass and clover onto three seedbed preparations for forage enhancement of broomsedge infested pastures.

MATERIALS AND METHODS

An overseeding split-plot design experiment with three replications was initiated in the fall of 1995 on six sites in southeastern Oklahoma. In fall of 1995, P_2O_5 and K_2O were applied according to soil test at all sites (Appendix A). Main plots in both 1995 and 1996 included: 1) mow in late summer, 2) paraquat application (0.5 lb ai/acre) plus burn in late summer, and 3) burning after frost. In 1995, mowing and paraquat plus burn treatments were applied in early September and burn after frost treatments were applied in late November. Subplots in 1995 included: 1) no overseeding 2) overseeding clovers ['Yuchi' arrowleaf (*Trifolium vesiculosum* Savi.), 'Overton R18' rose (*T. hirtum* All.), and 'Ladino' white clover (*T. repens* L.)], and 3) overseeding ryegrass (*Lolium multiflorum* Lam.'Marshall' and 'TAM90'). Yuchi, Overton R18, and Ladino clovers were seeded at 10, 10, and 4 lb pure live seed (PLS)/acre respectively, and Marshall and TAM90 were seeded at 25 lb PLS/acre. In early April 1996 clover and ryegrass plants were counted in four 12- by 24-in. quadrats per plot. In early May 1996, yield of clover was estimated by clipping one 12- by 24-in. quadrat in each plot at five of the six sites. Ryegrass yield was not estimated in May 1996 due to no emergence. The Ada site was not harvested due to cattle breaking into the fenced plots.

In 1996, main plots of paraquat plus burn and mow were applied in late August and overseeded in early September. Late frost delayed "burn after frost" main plots and seeding until mid-December to early January. Subplot treatments were altered in the fall of 1996 and included: no overseeding and a factorial combination of tillage and no tillage with two overseedings (Marshall ryegrass at 25 lb PLS/acre and a clover mix). The clover mix was a 5:5:5:2 lb PLS/acre mix of Yuchi arrowleaf, Overton R18 rose, red (*T. pratense* L.), and ladino white clover respectively. All sites were refertilized in the fall of 1996 according to soil P requirement with 18-46-0 and K requirement with 0-0-60 fertilizer. In December 1996, ryegrass and clover plants were counted using four 6- by 36-in. quadrats in the "mow" and "paraquat plus burn" treatments. All ryegrass plots received 30 lb/acre of N in January and 60 additional lb/acre in March 1997. In early March 1997, clovers and ryegrass plants were counted in the "burn after frost" plots using four 6- by 36-in. quadrats. In May 1997, clover, ryegrass, and other components were estimated for all plots and yields determined at five sites by clipping standing forage from two 18-by 36-in. quadrats in each plot. The Ada site was not harvested due to cattle breaking in and grazing the area to ground level. Data was analyzed using SAS® procedures (SAS Institute, 1996). ANOVA procedures were performed and treatment means were separated using least squares (LS) means at the 0.05 level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Dry conditions in the fall of 1995 and the spring of 1996 resulted in no emergence of ryegrass and erratic clover emergence (Table 1) and limited forage production (Table 2). Forage production of clover in paraquat plus burn main plot was equal to clover production in the mow main plot at three sites and better than mow at two sites (Table 2). Forage production in the burn after frost main plot was equal to the mow at two sites, but was always less than clover production in the paraquat plus burn treatment (Table 2). Establishment and forage production of Yuchi arrowleaf clover was generally better than either Overton R18 rose or ladino white clover. Only the "paraquat plus burn treatment" at the Antlers site yielded Yuchi clover production that approached 4,000 lb/acre (Table 2).

Improved moisture conditions in the fall of 1996 and winter of 1997 (Appendix B) resulted in better emergence and forage production of overseeded clover and ryegrass in yr 2. Clover density (Table 3) in yr 2 on untilled areas was generally higher with paraquat plus burn in late summer and burn after frost seedbed preparations than for mow in late summer at all sites ($P<0.10$). Clover yield was positively correlated with clover density in the "mow" ($r=0.8084$) and "paraquat plus burn" ($r=0.8273$) treatments. Clover yield, however, was not correlated with "burn after frost" densities ($r=-0.4930$). Clover production was highest ($P<0.05$) in the "paraquat plus burn" treatment at all five harvested sites (Tables 5-9) even though white tail deer kept the clover grazed to ground level until approximately March 1, 1997 at all sites except the Hugo site (Table 9). The seedlings that established in the fall apparently had an adequate root system to regrow and be more productive than seedlings that emerged in the "burn after frost" treatment which generally had the lowest yield ($P<0.05$).

Tillage had little effect on clover emergence or production in the "paraquat plus burn" or "burn after frost" treatments, however, tillage did improve clover density and production at two of the five sites in the "mow" treatment (Table 3). There was no difference ($P>0.10$) in clover density among "mow plus tillage" and "paraquat plus burn" treatments at four of the five sites (Table 3). The "paraquat plus burn" treatment, however, increased clover yields when compared to "mow plus tillage" treatment at four of the five sites harvested. Evidently the "paraquat plus burn" treatment was as effective as tillage for supressing existing vegetation and that allowed the new clover seedlings to be competitive and more productive. This is in agreement with Fribourg et al. (1978). They suggested that paraquat could be substituted for disking in a pasture renovation program.

At the Hartshorne site (Table 8) tall fescue suppressed the production of both clover and ryegrass in all plots except the "paraquat plus burn" treatment which eliminated the tall fescue. This is in agreement with Fribourg et al. (1978). They reported that 0.5 lb ai/acre paraquat reduced fescue standing crop by 95%.

Ryegrass emergence was higher in "paraquat plus burn" at five of the six sites and at all sites in the "burn after frost" treatments ($P<0.05$) when compared to the mow treatment. Ryegrass yield was not correlated with ryegrass plant density at the Hartshorne site, but were correlated with ryegrass plant densities at all other sites ($r=0.6916$ and 0.7045 for "mow" and "paraquat plus burn" treatments, respectively). Lack or correlation at the Hartshorne site was attributed to competition of tall fescue with seedling ryegrass. Ryegrass production was variable (Tables 5-9), but highest yields were generally in the "paraquat plus burn" treatment. Tillage improved ryegrass emergence ($P<0.05$) in the "mow" in late summer and "burn after frost" treatments at two of the five sites, and one of the five sites in the "paraquat plus burn" treatment (Table 4). Tillage generally did not improve ryegrass production. Ryegrass density was higher ($P<0.05$) with the "paraquat plus burn" treatment when compared to the "mow plus tillage" treatment at two of the five sites, and production was higher with the "paraquat plus burn" treatment at four of the five sites harvested. The "paraquat plus burn" treatment was as effective as tillage for supressing existing vegetation and this allowed the new ryegrass seedlings to be competitive and more productive.

Establishment of clover in the mow treatment appeared to be directly related to the amount of regrowth of the existing vegetation. As regrowth of existing vegetation increased, establishment of clover decreased. At the Durant site, regrowth was estimated at 1200 lb/acre which corresponded to 0.6 plants/sq ft in the mow treatment. At the Hugo site regrowth was estimated at 500 lb/acre which corresponded to 13.8 plants/sq ft in the mow treatment (Table 3). Regrowth taken after frost in the mow treatment ranged from 500 to 1200 lb/acre, while there was essentially no regrowth in the "paraquat plus burn" treatment except at the Antlers site. At this site, there was 490 lb/acre regrowth of bermudagrass at frost in the "paraquat plus burn" treatment which corresponded to 8.3 plants/sq ft which was higher than the mow treatment which averaged 900 lb/acre and 2.9 plants/sq ft (Table 3). Although bermudagrass regrowth occured at this site, there was no regrowth of broomsedge or any other bunchgrass. This is in agreement with what Ewing and Engle (1988) noted. They reported late-season burns tend to favor rhizomatous grass species while bunchgrasses are generally reduced by late-season fires.

The "burn after frost" treatment essentially eliminated other volunteer cool-season legumes such as hop clover (*Trifolium agrarium* L.) and vetch (*Vicia* sp. L.) when compared to the "paraquat plus burn" and "mow" treatments (Tables 5-9). The "paraquat plus burn" and "mow" treatments served as an adequate seedbed preparation for fall germinating legumes, whereas, "burn after frost" treatment would kill emerged small seedling legumes.

When averaged across all sites and conditions, the "paraquat plus burn" treatment produced the most forage and had the lowest production cost per ton of forage for both clover and ryegrass (Table 10). Tillage was only cost effective for clover production in the "mow" treatment and had little effect on cost of ryegrass production. Clover production costs per ton of forage produced was more cost effective than ryegrass production costs in the "paraquat plus burn" treatment and comparable to ryegrass costs in the "mow" treatment (Table 10). Cost of forage production in the "burn after frost" treatment was cost prohibitive, especially with clovers.

SUMMARY

Existing vegetation must be suppressed in order for cool-season forages to germinate and be competitive. Paraquat applied in late summer followed by burning makes an adequate seedbed preparation for clover and ryegrass since it removes most of the above-ground biomass and suppresses much of the growth of existing vegetation which allows cool-season forages to be more competitive and productive. In addition, paraquat applied with a prescribed fire has an advantage over tillage in that area is not subjected to as much erosion and soil surface is not roughed-up.

If fescue is present and the objective is not to reduce fescue, then it will require that paraquat be applied in strips or bands instead of over the entire area since it will severely damage fescue. It is important to obtain adequate densities of cool-season forages for maximum production, but with the lowest input costs for maximizing net returns. Clovers have an advantage in that they can reduce nitrogen (N) inputs by fixing atmospheric N and generally have higher nutritive values than grasses. A clover and ryegrass mixture could reduce the risk of disease and stand failure due to each species competitive ability to be more productive under certain environmental conditions. Ryegrass could utilize N that is provided by clover instead of other weedy species.

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Table 1. Clover density on April 11, 1996 for mow in late summer, paraquat plus burn in late summer, and burn after frost seedbed preparations at Ada, Antlers, Atoka, Durant, Hartshorne, and Hugo sites.

	Type of seedbed preparation		
Clover	Mow	Paraquat plus burn	Burn after frost
	plants/sq ft		
Ada site			
Yuchi	2.9 a†	2.5 a	0.1 b
Overton R18	1.6 ab	2.4 a	0.3 b
Ladino	0.2 b	0.9 b	0.0 b
Antlers site			
Yuchi	2.8 c	4.7 b	7.8 a
Overton R18	1.5 cd	4.2 bc	2.8 c
Ladino	0.9 d	4.2 bc	5.6 b
Atoka site			
Yuchi	11.0 a	5.2 b	1.6 d
Overton R18	4.8 b	3.6 c	0.5 e
Ladino	1.3 de	0.5 e	0.2 e
Durant site			
Yuchi	0.3 bc	0.3 bc	0.9 a
Overton R18	0.1 c	0.1 c	0.5 b
Ladino	0.1 c	0.2 bc	0.0 c
Hartshorne site			
Yuchi	3.2 b	6.1 a	0.6 c
Overton R18	0.6 c	1.4 c	0.1 c
Ladino	2.1 bc	2.8 b	1.0 c
Hugo site			
Yuchi	0.7 b	2.2 a	-‡
Overton R18	0.0 c	0.7 b	-
Ladino	0.0 c	0.0 c	-

† Means for all nine clover-seedbed combinations within site followed by the same letter do not significantly differ ($P<0.05$).

‡ Hugo was not burned after frost.

Table 2. Forage yield of clover on May 20, 1996 for mow in late summer, paraquat plus burn in late summer, and burn after frost seedbed preparations at Antlers, Atoka, Durant, Hartshorne, and Hugo sites.

	Type of seedbed preparation		
Clover	Mow	Paraquat plus burn	Burn after frost
	lb/acre		
Antlers site			
Yuchi	1710 bc†	3970 a	2240 b
Overton R18	1280 c	1660 bc	1250 c
Ladino	0 d	350 d	340 d
Atoka site			
Yuchi	1730 a	1970 a	288 b
Overton R18	1990 a	1710 a	160 b
Ladino	30 b	110 b	0 b
Durant site			
Yuchi	0 b	720 a	140 b
Overton R18	0 b	510 a	0 b
Ladino	0 b	0 b	0 b
Hartshorne site			
Yuchi	510 ab	310 b	0 b
Overton R18	160 b	750 a	0 b
Ladino	210 b	20 b	0 b
Hugo site			
Yuchi	2310 b	3040 a	-‡
Overton R18	540 c	1760 b	-
Ladino	0 c	0 c	-

† Means for all nine clover-seedbed combination within site followed by same letter do not significantly differ ($P<0.05$).

‡ Hugo was not burned after frost.

Table 3. Clover densities in the fall of 1996 for mow and paraquat plus burn in late summer treatments and in the spring of 1997 for burn after frost treatment at Ada, Antlers, Atoka, Durant, Hartshorne, and Hugo sites.

Treatment	Ada	Antlers	Atoka	Durant	Hartshorne	Hugo
	Sites					
	plants/sq ft					
Mow‡						
Tillage	17.8 b†	6.5 bc	3.6 ab	0.0 d	15.7 b	19.5 ab
No tillage	5.6 c	2.9 c	1.6 b	0.6 d	8.4 c	13.8 c
Paraquat + burn‡						
Tillage	34.2 a	10.4 a	4.1 ab	5.2 cd	23.0 a	22.2 ab
No tillage	18.3 b	8.3 ab	5.7 a	9.4 bc	16.3 b	24.7 a
Burn after frost§						
Tillage	8.1 c	5.5 bc	6.4 a	15.4 ab	14.4 b	13.0 c
No tillage	12.2 bc	8.9 ab	7.6 a	19.8 a	14.4 b	17.3 bc

† Means for all treatment combinations within a site followed by same letter do not differ (P<.10).

‡ Plants were counted in the fall before plants started tillering in the mow and paraquat plus burn treatment.

§ Plants were counted in the spring of 1997 before plants started tillering in the burn after frost treatment.

Table 4. Ryegrass densities in the fall of 1996 for mow and paraquat plus burn in late summer treatments and in the spring of 1997 for burn after frost treatment at Ada, Antlers, Atoka, Durant, Hartshorne, and Hugo sites.

Treatment	Ada	Antlers	Atoka	Durant	Hartshorne	Hugo
	plants/sq ft					
Mow						
Tillage	31.5 bc†	3.3 b	6.0 c	5.7 cd	19.0 c	11.3 b
No tillage	10.3 c	1.9 b	1.6 d	1.7 d	8.0 d	7.4 b
Paraquat + burn						
Tillage	46.4 a	4.3 b	6.0 c	9.5 c	38.2 a	29.7 a
No tillage	29.7 bc	5.0 b	8.6 c	8.0 c	27.6 b	24.5 a
Burn after frost						
Tillage	37.3 ab	21.4 a	15.7 a	31.1 a	19.3 c	28.4 a
No tillage	26.2 c	21.7 a	10.2 b	25.6 b	17.5 c	22.7 a

† Means for all treatment combinations within a site followed by same letter do not differ ($P<0.05$).

‡ Plants were counted in the fall before plants started tillering in the mow and paraquat plus burn treatment.

§ Plants were counted in the spring of 1997 before plants started tillering in the burn after frost treatment.

Table 5. Forage yield of clover mix, ryegrass, other legumes, broadleaf weeds, other grasses and total production in early May 1997 on seedbed preparations of mow in late summer, paraquat plus burn in late summer, and burn after frost at Antlers.

Treatment	Clover	Ryegrass	Other legumes	Broadleaf weeds	Other grass	Total
			lb/acre			
Mow						
No overseeding	-	-	1360 a	620 ab	290 bc	2270 bc
Clover overseeding	1380 bc	-	390 bc	230 cd	290 bc	2300 bc
Clover + tillage	1660 b	-	230 c	190 cd	180 bc	2250 bc
Ryegrass overseeding	-	1190 bc	740 b	490 abc	430 ab	2850 ab
Ryegrass + tillage	-	830 c	410 bc	710 a	720 a	2660 abc
Paraquat + burn						
No overseeding	-	-	700 b	310 bcd	160 bc	1170 cd
Clover overseeding	2620 a	-	240 c	150 cd	240 bc	3250 ab
Clover + tillage	3310 a	-	150 c	70 d	70 c	3600 a
Ryegrass overseeding	-	1750 b	830 b	460 abc	280 bc	3320 ab
Ryegrass + tillage	-	1010 c	910 ab	400 abcd	310 bc	2630 abc
Burn after frost						
No overseeding	-	-	120 c	220 cd	330 bc	670 d
Clover overseeding	1050 bc	-	40 c	120 cd	210 bc	1420 cd
Clover + tillage	590 c	-	10 c	130 cd	120 c	840 d
Ryegrass overseeding	-	3000 a	170 c	330 bcd	350 bc	3840 a
Ryegrass + tillage	-	2650 a	130 c	140 cd	250 bc	3170 ab

† Means for all treatment combinations within column followed by same letter do not differ (P<0.05).

‡ Plants were counted in the fall before plants started tillering in the mow and paraquat plus burn treatment.

§ Plants were counted in the spring of 1997 before plants started tillering in the burn after frost treatment.

Table 6. Forage yield of clover mix, ryegrass, other legumes, broadleaf weeds, other grasses and total production in early May 1997 on seedbed preparations of mow in late summer, paraquat plus burn in late summer, and burn after frost at Atoka.

Treatment	Clover	Ryegrass	Other legumes	Broadleaf weeds	Other grass	Total
	lb/acre					
Mow						
No overseeding	-	-	490 ab	140 cd	590 ab	1220 defg
Clover overseeding	1290 b	-	230 bc	200 bcd	200 c	1920 bcd
Clover + tillage	1270 b	-	280 abc	110 d	150 c	1810 cde
Ryegrass overseeding	-	1120 c	260 abc	440 ab	800 a	2620 abc
Ryegrass + tillage	-	1550 bc	550 a	290 abcd	880 a	3280 a
Paraquat + burn						
No overseeding	-	-	80 c	440 ab	90 c	600 g
Clover overseeding	2010 a	-	80 c	140 cd	100 c	2320 bc
Clover + tillage	1860 a	-	150 c	80 d	100 c	2180 bc
Ryegrass overseeding	-	1810 b	290 abc	260 bcd	220 c	2570 abc
Ryegrass + tillage	-	1800 b	340 abc	410 abc	200 c	2760 ab
Burn after frost						
No overseeding	-	-	0 c	630 a	300 bc	920 fg
Clover overseeding	1180 bc	-	0 c	180 bcd	160 c	1520 def
Clover + tillage	710 c	-	0 c	140 cd	160 c	990 efg
Ryegrass overseeding	-	1540 bc	0 c	420 ab	330 bc	2300 bc
Ryegrass + tillage	-	2800 a	0 c	320 abcd	280 bc	3390 a

† Means for all treatment combinations within column followed by same letter do not differ (P<0.05).

‡ Plants were counted in the fall before plants started tillering in the mow and paraquat plus burn treatment.

§ Plants were counted in the spring of 1997 before plants started tillering in the burn after frost treatment.

Table 7. Forage yield of clover mix, ryegrass, other legumes, broadleaf weeds, other grasses and total production in early May 1997 on seedbed preparations of mow in late summer, paraquat plus burn in late summer, and burn after frost at Durant.

Treatment	Clover	Ryegrass	Other legumes	Broadleaf weeds	Other grass	Total
	lb/acre					
Mow						
No overseeding	-	-	90 b	110 cd	450 abc	640 f
Clover overseeding	190 c	-	110 b	120 bcd	630 a	1050 f
Clover + tillage	560 c	-	0 b	210 bcd	220 bc	990 f
Ryegrass overseeding	-	4170 a	80 b	310 ab	480 ab	5040 a
Ryegrass + tillage	-	2940 bc	120 b	130 bcd	270 abc	3450 bc
Paraquat + burn						
No overseeding	-	-	560 a	200 bcd	480 ab	1240 f
Clover overseeding	2840 a	-	250 b	40 d	110 bc	3250 cd
Clover + tillage	2070 b	-	10 b	120 bcd	150 bc	2350 de
Ryegrass overseeding	-	3570 ab	310 ab	80 cd	280 abc	4240 ab
Ryegrass + tillage	-	2790 c	120 b	140 bcd	370 abc	3420 bc
Burn after frost						
No overseeding	-	-	0 b	420 a	180 bc	600 f
Clover overseeding	430 c	-	0 b	210 bcd	100 c	730 f
Clover + tillage	560 c	-	0 b	160 bcd	70 c	780 f
Ryegrass overseeding	-	2310 cd	0 b	180 bcd	290 abc	2780 cde
Ryegrass + tillage	-	1750 d	0 b	260 abc	250 bc	2260 e

† Means for all treatment combinations within column followed by same letter do not differ (P<0.05).
‡ Plants were counted in the fall before plants started tillering in the mow and paraquat plus burn treatment.
§ Plants were counted in the spring of 1997 before plants started tillering in the burn after frost treatment.

Table 8. Forage yield of clover mix, ryegrass, other legumes, broadleaf weeds, other grasses and total production in early May 1997 on seedbed preparations of mow in late summer, paraquat plus burn in late summer, and burn after frost at Hartshorne.

Treatment	Clover	Ryegrass	Other legumes	Broadleaf weeds	Other grass	Fescue	Total
				lb/acre			
Mow							
No overseeding	-	-	90 b	360 bc	470 a	980	1900 de
Clover overseeding	840 c	-	0 b	450 bc	320 a	530	2150 cde
Clover + tillage	1800 b	-	160 b	170 c	410 a	460	2990 bc
Ryegrass overseeding	-	300 c	0 b	300 cd	450 a	1880	2940 bcd
Ryegrass + tillage	-	1820 b	130 b	180 c	120 a	1450	3770 b
Paraquat + burn							
No overseeding	-	-	460 a	940 a	210 a	0	1610 ef
Clover overseeding	2910 a	-	0 b	260 cd	370 a	0	3540 b
Clover + tillage	3010 a	-	0 b	120 c	220 a	0	3420 b
Ryegrass overseeding	-	3690 a	90 b	440 bc	420 a	0	4630 a
Ryegrass + tillage	-	4660 a	60 b	80 c	120 a	0	4930 a
Burn after frost							
No overseeding	-	-	0 b	260 cd	200 a	560	1020 f
Clover overseeding	460 c	-	0 b	210 c	190 a	170	1020 f
Clover + tillage	440 c	-	0 b	190 c	100 a	110	830 f
Ryegrass overseeding	-	400 c	40 b	720 ab	470 a	740	2370 cde
Ryegrass + tillage	-	660 c	40 b	400 bc	530 a	500	2120 de

† Means for all treatment combinations within column followed by same letter do not differ (P<0.05).

‡ Plants were counted in the fall before plants started tillering in the mow and paraquat plus burn treatment.

§ Plants were counted in the spring of 1997 before plants started tillering in the burn after frost treatment.

Table 9. Forage yield of clover mix, ryegrass, other legumes, broadleaf weeds, other grasses and total production in early May 1997 on seedbed preparations of mow in late summer, paraquat plus burn in late summer, and burn after frost at Hugo.

Treatment	Clover	Ryegrass	Other legumes	Broadleaf weeds	Other grass	Total
	lb/acre					
Mow						
No overseeding	-	-	120 b	80 b	530 ab	730 hi
Clover overseeding	2910 b	-	100 b	110 ab	260 bc	3380 ef
Clover + tillage	4770 a	-	20 b	50 b	110 c	4940 de
Ryegrass overseeding	-	5620 c	20 b	60 b	280 abc	5980 cd
Ryegrass + tillage	-	5550 c	130 b	110 ab	620 a	6420 bc
Paraquat + burn						
No overseeding	-	-	1320 a	300 a	80 c	1700 gh
Clover overseeding	4940 a	-	30 b	20 b	30 c	5020 d
Clover + tillage	5260 a	-	0 b	40 b	50 c	5360 cd
Ryegrass overseeding	-	7080 b	150 b	100 ab	30 c	7350 ab
Ryegrass + tillage	-	7790 a	50 b	50 b	0 c	7900 a
Burn after frost						
No overseeding	-	-	0 b	80 b	150 c	230 i
Clover overseeding	410 c	-	0 b	80 b	140 c	620 hi
Clover + tillage	260 c	-	0 b	130 ab	30 c	410 i
Ryegrass overseeding	-	1620 d	0 b	310 a	160 c	2090 g
Ryegrass + tillage	-	1930 d	0 b	310 a	20 c	2250 fg

† Means for all treatment combinations within column followed by same letter do not differ (P<0.05).

‡ Plants were counted in the fall before plants started tillering in the mow and paraquat plus burn treatment.

§ Plants were counted in the spring of 1997 before plants started tillering in the burn after frost treatment.

Table 10. Average costs, yields, and production costs per ton across all sites for seedbed preparations of mow, paraquat plus burn, and burn after frost for both clover and ryegrass.

Treatment	Inputs†	Costs	Yield	Production
		$/acre	lb/acre	$/ton
Mow				
Clover mix	1+2+3+8	37.00	1300	56.9
Disk + clover	1+2+3+7+8	43.00	2000	43.0
Ryegrass	1+2+3+9+10	65.15	2480	52.5
Disk + ryegrass	1+2+3+7+9+10	71.15	2540	56.0
Paraquat plus burn				
Clover mix	1+2+4+5+6+8	43.62	3060	28.5
Disk + clover	1+2+4+5+6+7+8	49.62	3120	31.8
Ryegrass	1+2+4+5+6+9+10	71.82	3580	40.1
Disk + ryegrass	1+2+4+5+6+7+9+10	77.82	3610	43.1
Burn after frost				
Clover mix	1+2+6+8	34.00	710	95.8
Disk + clover	1+2+6+7+8	40.00	510	156.9
Ryegrass	1+2+6+9+10	62.15	1770	70.2
Disk + ryegrass	1+2+6+7+9+10	68.15	1960	69.5

† 1. 55 lb P_2O_5 @ $0.26/lb = $14.30/acre
2. 30 lb K_2O @ $0.13/lb = $3.90/acre
3. Mow = $6.00/acre
4. 1.5 pt paraquat @ $35.28/gallon = $6.62/acre
5. Application costs = $3.00/acre
6. Burn = $3.00/acre
7. Disk = $6.00/acre
8. Clover seed = 8 lb/acre @ $1.60 = $12.80/acre
9. Ryegrass seed = 25 lb/acre @ $0.45 = $11.25/acre
10. 90 lb N @ $0.33 = $29.70/acre

CHAPTER IV

BROOMSEDGE RESPONSE TO HERBICIDES AND LATE SEASON BURNING

Broomsedge Response to Herbicides and Late Season Burning

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Broomsedge (*Andropogon virginicus* L.) is generally considered to have low grazing value for cattle. Three herbicide experiments were initiated at six sites in the spring and fall of 1995. In early April of 1995, glyphosate was applied at 2.0 lb ai/acre, and paraquat was applied at 0.5 lb ai/acre. Glyphosate in the spring decreased broomsedge stem density where cattle had previously grazed, and where fire had removed old growth before spraying. Poor broomsedge control resulted on sites with large amounts of old standing material. Paraquat applied in the spring had little effect on broomsedge. In early September glyphosate was evaluated at 0.5 lb ai/acre and 1.0 lb ai/acre. Glyphosate applied in September reduced broomsedge stems by 69 and 89% for 0.5 and 1.0 lb/acre rates, respectively.

Treatments in a burning experiment initiated at all six sites in the fall of 1995 included: 1) mowing in late summer, 2) paraquat application plus burn in late summer, and 3) burn after frost. Paraquat was applied at 0.5 lb ai/acre followed by

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a prescribed fire. The mow and paraquat treatments were applied in September while the burn after frost treatment was possible in late November of 1995 at four of the six sites. Paraquat plus burn in the fall decreased broomsedge stem densities the first yr at four of the six sites, and burning after frost significantly decreased broomsedge stem densities at three of the five sites.

Broomsedge (*Andropogon virginicus* L.) is a native, warm-season, short-lived perennial bunchgrass growing on millions of acres of pastureland in the southeastern United States. Herbicides can be used to accelerate the process of pasture renovation. Vaught et al. (1977) reported that 0.5 lb ai/acre of paraquat reduced broomsedge standing crop from 10 to 45% when applied from May to September. Albert (1965) reported that paraquat desiccated bermudagrass, but bermudagrass promptly regrew without any noticeable injury from the paraquat. Vaught et al. (1977) also reported that 0.5 lb ai/acre of glyphosate applied from May to September reduced broomsedge standing crop by 70-80%, and 1.0 lb ai/acre resulted in over 90% control except when applied in early May. They also reported that glyphosate at 2.0 lb ai/acre only produced 10% more control than 0.5 lb ai/acre. Johnson and Ware (1978) reported that bermudagrass was injured by glyphosate when evaluated 3 weeks after treatment (WAT), but fully recovered 6 WAT from 0.34 lb ai/acre and 9 WAT from 0.67 lb ai/acre.

Thurman (1969) reported very little effect of spring burning on broomsedge production. He found that burning in spring reduced yield of broomsedge 200 lb/acre compared with a mow treatment the first yr. By the second and the third yr of his experiment, however, there were no differences in forage production of broomsedge between the two treatments. There has been little work done on the effects of late-season burning on broomsedge. Since broomsedge has a similar growth form to little bluestem [*Schizachyrium scoparium* (Michx.) Nash], it is possible that fall burning might be effective in supressing broomsedge. Engle et al. (1993) reported that little bluestem's caespitose growth habit make its buds susceptible to late season burns. Ewing and Engle (1988) reported that burning little bluestem in September reduced its vigor. The purpose of these experiments was to determine to effectiveness of herbicides, herbicide plus late summer burning, and burning after frost on reducing the vigor of broomsedge.

MATERIALS AND METHODS

Three herbicide experiments consisting of a randomized complete block design were initiated at six broomsedge infested sites, one in the spring of 1995 with two replications and two in late summer of 1995 with three replications. Broomsedge infestations were determined for all sites in the spring of 1995 before spring treatments were applied to by counting broomsedge plants in four 18- by 36-in. permanent quadrats. On April 6, 1995, glyphosate was applied at 2.0 lb ai/acre and paraquat was applied at 0.5 lb ai/acre to the Antlers, Atoka, Durant, and Hartshorne plots that had standing dead material, and to the Ada site which had been heavily grazed prior to application of herbicides. Herbicides were applied May 19, 1995 to the Hugo site which had been burned in the spring prior to application of herbicides. Plant counts were taken in the permanent quadrats in August 1995 to determine activity of spring applied herbicides. Forage yields were taken on June 28, 1996, at five of the six sites to determine herbicide effects 2 yr after treatment (YAT). The Hugo site was not harvested due to cattle breaking into the fenced plots and grazing the forage, thus, preventing data collection. Stem counts were also taken in August 1996 to determine herbicide effects on stem density 2 YAT.

The late summer experiments were initiated September 15, 1995. In one experiment, glyphosate was applied to evaluate broomsedge control at the 0.5 lb ai/acre and 1.0 lb ai/acre rates. In the other experiment, the effects of mowing in late summer, paraquat plus burn in late summer, and burning after frost were evaluated for broomsedge control. Paraquat was applied at 0.5 lb ai/acre on September 15, and then burned approximately 1 WAT. All applications were made using a CO_2 backpack sprayer at 38 psi traveling 3.3 mph. In late November, the burn after frost treatment was possible at four of the six sites. Burn after frost treatment was not applied to the Hugo site, and the Antlers site was only partially burned due to wet conditions at the time of burning. In the spring of 1996, herbicide experiments were burned to remove dead material. Broomsedge stem density was estimated in all three experiments in August 1996 by counting broomsedge stems in four 18- by 36-in. quadrats in each plot that had initiated flowering stalks. Data was analyzed using SAS® procedures (SAS Institute, 1996). ANOVA procedures were performed and treatment means were separated using a Fisher's protected LSD at the 0.05 level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Glyphosate applied in the spring decreased broomsedge stem density where cattle had previously grazed and where fire had removed old growth before spraying (Table 1). Poor broomsedge control based on plant and stem density resulted on sites with large amounts of residual standing material at time of treatment. This was attributed to inadequate coverage of new growth due to interference of the old standing crop of broomsedge plants. Paraquat applied in the spring had little effect on density and production of broomsedge ($P>0.10$). Glyphosate reduced broomsedge production ($P<0.05$) 1 YAT at all sites when compared to the no herbicide and paraquat treatments. When averaged across all sites, broomsedge production averaged 620 lb/acre in the glyphosate treatment compared with 1010 lb/acre in the no herbicide treatment and 1140 lb/acre in the paraquat treatment. Total forage production 1 YAT was not effected ($P>.10$) by either paraquat (1520 lb/acre) or glyphosate (1310 lb/acre) when compared with the no herbicide treatment (1460 lb/acre).

Both rates of glyphosate applied in late summer to flowering plants reduced broomsedge stems ($P<.0001$) at all six sites. Broomsedge stems averaged over sites were reduced from 26 stems/sq ft for no herbicide treatment to 8 and 3 stems/sq ft for 0.5 and 1.0 lb ai/acre glyphosate rate respectively. The 1.0 lb ai/acre rate of glyphosate resulted in greater reduction than 0.5 lb ai/acre rate ($P<0.10$). Some injury to bermudagrass was noted in the fall with both rates of glyphosate, but no injury was noted the following spring. Flowering broomsedge plants occupied most of the overstory vegetation on these broomsedge infested areas so they would intercept much of the herbicide and minimize the effect on shorter growing species like bermudagrass.

Paraquat plus burn significantly decreased broomsedge stem density 60% to 97% at four of the six sites when compared to the mow treatment (Table 2). Burning after frost decreased broomsedge stem density from 50% to 70% at four of five sites when compared with the mow in late summer treatment. Stems were not reduced in the burn after frost treatment at the Antlers site. This was attributed to extremely wet conditions at time of burning which only allowed this treatment to partially burn. At the Hartshorne site, reductions in broomsedge stems were not significant ($P>0.10$) due to variation in broomsedge stand (Table 2). At the Hugo site, there was little reduction in broomsedge stems with the paraquat plus burn treatment. This may be related to the fact that this was a wet site in a low poorly drained area with a silty clay soil texture that would retain more moisture.

Bermudagrass growth the following spring did not appear to be affected by either paraquat plus burning or burning after frost treatments. This is in agreement with what Ewing and Engle (1988) noted. They reported late-season burns tended to favor rhizomatous grass species such as switchgrass (*Panicum virgatum* L.) and indiangrass [*Sorghastrum nutans* (L.) Nash], while bunchgrasses were generally reduced by late-season fires. Soil moisture plays a very important roll in determining injury of bunchgrasses by late-season fires. Since broomsedge has a caespitose growth form, late season burns may injure broomsedge. It is believed that dry conditions, which occurred in the fall of 1995 (Appendix B), would increase the damage of burning to broomsedge.

SUMMARY

Treatments of glyphosate and paraquat plus burn applied in late summer to broomsedge infested pastures would speed the renovation process on areas with bermudagrass in the understory. Broomsedge was suppressed by glyphosate applied to flowering plants in late summer, while bermudagrass appeared fully recovered by the next spring. The taller broomsedge plants intercepted much of the herbicide, thus minimizing injury to bermudagrass. Paraquat applied in the fall with burning approximately 1 wk later paraquat suppressed broomsedge stem density. Desiccation of plants with paraquat allows burning to occur earlier in the season when other vegetation is still green, thus reducing the hazard of fire escaping. Paraquat and burning 1 wk later had little effect on bermudagrass since late summer burns tend to favor rhizomatous species when compared to bunchgrasses. In addition, herbicide treatment in late summer followed burning would allow for early seeding of cool-season species in time for the fall rains which typically come in September.

Use of herbicides in the spring would not be a good option on broomsedge infested pastures. Paraquat applied in the spring had little effect on broomsedge, and glyphosate was not effective on areas where old standing crop of broomsedge existed. Some suppression of broomsedge was obtained on areas where adequate herbicide coverage of new broomsedge plants was possible (grazed and burned areas), however, spring applications on these type of areas would suppress and damage desirable forage species as well. If no desirable species are present then spring applied glyphosate could be used to kill existing vegetation for renovation by interseeding a desirable forage species.

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Table 1. Effects of spring applied paraquat and glyphosate on broomsedge density in August 1995 and 1996 at Atoka, Durant, Antlers, Hartshorne, Ada, and Hugo sites.

Condition of site	1995	1996‡
	— plants/sq ft —	— stems/sq ft —
Old standing material left (Av. of 4 sites)		
No herbicide	1.3 a†	5.0 a
0.5 lb ai/acre paraquat	1.4 a	6.4 a
2.0 lb ai/acre glyphosate	1.0 a	5.1 a
Heavily grazed (Ada)		
No herbicide	3.5 a	4.3 a
0.5 lb ai/acre paraquat	3.7 a	3.3 a
2.0 lb ai/acre glyphosate	1.6 b	0.9 b
Applied after burn (Hugo)		
No herbicide	1.8 a	7.3 a
0.5 lb ai/acre paraquat	1.4 a	10.6 a
2.0 lb ai/acre glyphosate	0.1 b	1.8 b

† means within pretreatment condition and yr followed by same letter do not differ ($P<0.05$).

‡ 1996 data is 2 yr after treatment.

Table 2. Effects of mow in late summer, paraquat plus burn in late summer, and burn after frost in 1995 on broomsedge stem density in August 1996.

Site	Mow	Paraquat+ burn	Burn after frost
		stems/sq ft	
Ada	5.2 a†	2.1 b	2.7 b
Antlers	4.4 a	0.9 b	5.1 a‡
Atoka	7.2 a	0.2 c	3.0 b
Durant	10.5 a	2.5 b	3.0 b
Hartshorne	6.6 a	4.2 a	2.2 a
Hugo	8.5 a	7.8 a	-§

† Means within site followed by same letter do not differ ($P<0.05$).

‡ Antlers site was only partially burned due to wet conditions

§ Hugo site was not burned after frost.

APPENDIX

Appendix A. Soil, texture, pH, buffer index, N, P, K, and soil test recommendations for Ada, Antlers, Atoka, Durant, Hartshorne, and Hugo sites at initiation of experiments in April 1995.

	Site					
Parameter	Ada	Antlers	Atoka	Durant	Hartshorne	Hugo
Soil classification	Dennis	Bernow Romia	Hamden	Matoy	Choteau	Hollywood Swink
Texture†	fine sandy loam	fine sandy loam	fine sandy loam	silty clay loam	fine sandy loam	silty clay
pH	5.3	5.3	6.0	6.0	6.3	5.5
Buffer index	6.9	6.7	6.9	6.7	7.2	6.5
NO3-N (lb/acre)	2	1	2	3	1	5
P index‡	11	13	7	19	17	8
K index ‡	155	179	331	421	151	168
Soil test recomendation§						
P2O5 lb/acre	58	56	65	42	46	63
K2O lb/acre	42	34	0	0	43	39

† Soil type and texture are from the USDA Soil Survey from each county.

‡ Index equals parts per 2 million or lb/acre.

Appendix B. The 30-yr mean precipitation (in.) for the growing season of six sites in southeastern Oklahoma compared to 1995-96 and 1996-97 growing season precipitation totals at Ada, Antlers, Atoka, Hartshorne, and Hugo sites.

	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
30 yr mean	4.25	3.18	3.07	4.84	3.79	2.83	2.68	1.99	2.71	3.17	4.81	5.77
1995-96												
Ada	2.09	6.92	0.56	8.12	0.7	0.84	2.28	1.82	0.05	3.14	6.44	0.35
Antlers	3.22	3.55	1.06	7.97	2.21	1.51	3.29	0.28	4.47	4.44	1.50	2.84
Atoka	3.37	3.24	1.67	5.57	1.38	1.05	3.23	3.0	0.11	2.88	4.36	1.68
Durant	4.24	2.77	0.17	6.54	1.24	1.46	3.59	1.87	0.0	2.89	5.97	0.20
Hartshorne	6.32	3.57	0.30	5.93	1.87	0.98	1.87	2.64	0.22	3.18	7.83	3.37
Hugo	1.39	2.74	1.04	5.78	0.62	1.08	2.88	3.09	0.11	2.98	3.34	1.98
1996-97												
Ada	4.42	8.42	8.42	5.19	2.39	4.68	0.38	0.24	5.28	0.97	4.80	4.07
Antlers	2.84	6.96	9.93	7.35	10.91	13.64	1.49	0.70	6.45	2.16	5.42	10.57
Atoka	3.56	9.89	10.36	6.80	8.35	10.65	0.74	0.83	5.81	2.51	4.95	6.49
Durant	5.68	5.95	7.76	6.30	6.77	10.32	0.73	0.86	6.13	3.39	6.12	2.99
Hartshorne	4.04	7.65	2.10	4.87	1.89	9.44	0.78	0.47	5.46	2.54	3.50	4.44
Hugo	5.74	9.83	6.39	7.70	7.61	12.39	1.14	0.88	5.94	5.40	6.86	3.86

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