Sod Suppression Techniques for Legume Interseeding[1]

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Summary

Sod suppression is necessary for successful establishment of legumes interseeded into existing pasture; however such techniques vary in their effectiveness, cost, and management. Sod suppression experiments for legume interseeding into cool-season pasture were conducted at South Dakota State University's Cow-Calf Unit located near Brookings, SD in 2003 to 2005. We evaluated (i) spring burn, (ii) field cultivator or disk, (iii) herbicide, (iv) heavy fall and spring graze, and (v) a control with no sod suppression. Legume species were alfalfa, birdsfoot trefoil, and kura clover. Sod suppression techniques enhanced the success of legume interseeding. In this study, the grazing equaled or was better than herbicide as a sod suppression technique. Field cultivating, disking or spring burning did not enhance the success of legume establishment. Alfalfa had a greater establishment in the drier year of 2003. Birdsfoot trefoil had greater establishment in the wetter year of 2004. Kura clover was not successful in establishment. Costs of sod suppression techniques varied from $0 per acre (grazing) to $13.30 per acre (herbicide). Management of sod suppression techniques is important to provide a long enough window for legumes to establish with minimal competition from existing grass. Managers can choose the sod suppression technique and legume that fits their resources, skills, and comfort level to achieve successful legume interseeding.

Introduction

Legumes grown in combination with grass pasture have been shown to be very beneficial for increased livestock production. Forage legumes can reduce annual nitrogen fertilizer application through their ability to fix nitrogen (Alexander and McCloud, 1962). Estimates of nitrogen fixation for forage legumes in grass pasture range from 70 to 100 lb N per acre (Matches, 1989; Burton and DeVane, 1992). Forage nutritive value of cool-season grass pastures has been shown to improve when forage legumes are grown in the sward because nutritive value of legumes tends to be higher than grasses (Sanderson and Wedin, 1989; Ullerich et al., 2002). Grass-legume pastures have been shown to provide a more uniform seasonal distribution of forage than grass pastures (Sheaffer et al., 1990; Gerrish, 1991; Belsky and Wright, 1994). All of these factors are responsible for better animal performance on grass-legume pasture versus pure grass pasture. An extensive review of grazing studies in the temperate northern USA has shown higher average daily gain on grass-legume pastures (1.43 lb per day) versus pure grass pasture (1.30 lb per day), even when nitrogen fertilizer was added (Burns and Bagley, 1996). Unfortunately, successful establishment practices and stand persistence are not fully understood, especially under diverse management systems. A better understanding of these factors and how they govern the complex establishment process will improve our knowledge of legume-grass pasture resources.

The suppression of existing vegetation with herbicides and the development of new planting methods have greatly increased the success of inter-seeding legumes (Moshier and Penner 1978; Olsen et al., 1981; Cuomo et al., 2001; Seguin et al., 2001). Establishment success is still limited by seedling vigor, lack of moisture, high temperatures, low fertility, low pH, diseases, and winter-killing (Vough et al., 1995). It is clear from various studies (Kunelius et al., 1982; Cuomo et al., 2001; Seguin et al., 2001) that competition from existing vegetation is the main constraint to establishment. Costs, performance, and effects on the environment are reasons why alternative methods to herbicides are desirable to control existing grass

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competition. These may not always be as successful as herbicides (Kunelius et al., 1982). Very little is known about the use of burning or grazing as sod suppression techniques to interseed legumes. The objectives of this study were to examine the establishment success and economics of four sod suppression techniques for the establishment of legumes in smooth bromegrass (*Bromus inermis* Leyss.)/Kentucky bluegrass (*Poa pratensis* L.) dominated pastures in eastern South Dakota.

Materials and Methods

Two experiments were conducted from 2002 through 2005 at South Dakota State University's Cow-Calf Unit located near Brookings, SD. The pasture vegetation was dominated by smooth bromegrass and Kentucky bluegrass with minor amounts of intermediate wheatgrass [*Elytrigia intermedia* (Host) Nevski subsp. *intermedia*] and quackgrass [*Elytrigia repens* (L.) Desv. ex Nevski] on a Fordtown-Spottswood loam soil (Fine-loamy over sandy, mixed Pachic Udic Haploborolls). Climate is continental with a monthly mean maximum temperature of 82^{o}F occurring in July and a monthly mean minimum temperature of 11^{o}F in January from a 30 yr (1975-2004) average (USDC, 2004). Average annual precipitation is 23.2 in with June being the wettest month and 79% of the annual precipitation occurring between April and September (USDC, 2004).

The experimental design was a randomized complete block with four replications for both experiments. Treatments were arranged in a split plot design with sod suppression method as the whole plot and legume species as the subplot. Whole plot experimental units were 20 x 44 ft in Experiment I and 20 x 28 ft in Experiment II. Subplot experimental units were plots 12 x 20 ft. Alleyways 4 ft wide separated each subplot. In Experiment I, sod suppression treatments were (i) spring burn conducted immediately after seeding, (ii) field cultivate with 6 in sweeps spaced 9 in apart that dug approximately 4 in deep immediately prior to seeding, (iii) herbicide application of glyphosate [isopropyl amine of N-(phosphono-methyl) glycine] at 0.5 lb of active ingredient per acre applied immediately after seeding, (iv) heavy fall and spring graze, and (v) a control with no sod suppression. Beginning graze dates for the heavy fall and spring graze treatment were 26 August 2002 and 16 May 2003. Grazed plots in the fall were stocked with two beef heifers weighing approximately 1000 lb for 1 day by fencing a 40 x 40 ft area (56 animal unit days, AUD pre acre) to achieve a residual vegetation height of < 2 in. The same areas were grazed in the spring with a cow-calf pair weighing approximately 1400 lb for 2 d (78 AUD per acre). In Experiment II, sod suppression treatments were (i) spring burn conducted immediately after seeding, (ii) disk approximately 4 in. deep immediately prior to seeding, (iii) herbicide application of glyphosate at 0.5 lb of active ingredient per acre applied immediately after seeding, (iv) heavy fall and spring graze, and (v) a control with no sod suppression. Beginning graze dates for the heavy fall and spring graze treatment were 4 September 2003 and 30 April 2004. Grazed plots in the fall were stocked with a beef heifer weighing approximately 1000 lb for 1 d (28 AUD per acre). The same areas were grazed in the spring after seeding with a cow-calf pair weighing approximately 1400 lb for 2 d (78 AUD per acre). Both experiments were fenced after seeding and no defoliation occurred until July of the second year.

Seeding date for Experiment I and Experiment II was 16 May 2003 and 30 April 2004, respectively. In Experiment I, seeding rate for 'Ameristand 403+Z' alfalfa (*Medicago sativa* L.), 'Norcen' birdsfoot trefoil (*Lotus corniculatus* L.), and 'Endura' kura clover (*Trifolium ambiguum* Bieb.) was 10, 10, and 12 lb per acre respectively. In Experiment II, Ameristand 403+z alfalfa and Norcen birdsfoot trefoil were seeded at 10 lb per acre each. Plots were seeded with an 8 row, 5 ft wide Truax FlexII No-till drill (Truax Company Inc., New Hope, MN).

Stand counts were collected in late June during the establishment year and one year after establishment in mid-May for each experiment. Stand data were collected from the middle 4 rows of the drill pass using a 24 x 30 in frame divided into 20 squares. Eight samples were taken from each subplot. Frequency of occurrence for each subplot was calculated by tallying the number of squares that contained live-rooted plants of planted species and divided by 160. Plant density was estimated by assuming that presence of one rooted plant per 20, 6 x 6 in, squares or 5% occurrence equaled 0.2 plants per ft^2. Herbage biomass was estimated one year after establishment on 4 June 2004 in Experiment I and on 11 July 2005 in Experiment II by clipping vegetation near the soil surface from four 3.9-ft square frames per subplot. Samples were dried in a forced air oven at 140°F for 72 hours. Samples were weighed and yield was calculated.

Frequency of occurrence during the year of establishment, one year after establishment, and biomass were analyzed separately for each experiment using analysis of variance procedures. A split plot model was calculated using PROC MIXED (SAS, 1999). Sod suppression treatment and species were considered fixed effects and block and block x sod suppression treatment were considered random effects. Least square means and standard errors were calculated using the LSMEANS statement and separated using the PDIFF option (SAS, 1999). Mean comparisons were considered significantly different at $P \leq 0.05$.

Results and Discussion

Climate

Establishment year temperatures for each experiment during the growing season were slightly below the 30-yr average (Table 1) and very favorable for establishment of cool-season species. The daily maximum temperature during this period reached > 90°F only 16 and 4 times, in 2003 and 2004, respectively (data not shown). Precipitation was 4.5 in below the 30-yr normal in 2003, but was 1.8 in above normal in 2004. Precipitation was very timely in 2004 with twice the normal precipitation falling in May and above normal precipitation in July (Table 1). Both years were below normal in August and September precipitation was above normal.

Sod Suppression

To equate the frequency of occurrence to a density measurement (plants per ft^2) in this study, one multiplies the frequency of occurrence x 20 squares divided by 5 ft^2. A 25% frequency of occurrences equals 1 plant per ft^2 which we considered an acceptable stand. The success of species establishment varied across different sod suppression techniques as indicated by a significant ($P < 0.01$) sod suppression by species interaction for frequency of occurrence during the year of establishment in Experiment I, Experiment II, and one year after establishment in Experiment I but not in Experiment II. Since the rankings of species remained constant among sod suppression treatments in both experiments, the presence of the interactions would not be expected to change the conclusions drawn from the different sod suppression techniques used for these species.

Fall and spring graze treatment had the greatest ($P = 0.05$) legume frequency of occurrence during the year of establishment in Experiment I (Table 2). Field cultivate had the second greatest legume frequency of occurrence followed by burn, herbicide and no sod suppression. In Experiment II, fall and spring graze, herbicide, and no sod suppression treatment had the greatest ($P = 0.05$) frequency of occurrence of legumes during the establishment year (Table 2). Frequency of occurrence was less ($P = 0.05$) in burn and disk treatments.

Estimated plant density during the year of establishment for fall and spring graze treatment averaged approximately 3 plants per ft^2 over both experiments. Similar graze treatments by Seguin et al. (2001) produced plant density of clover species (*Trifolium* spp.) equal to herbicide or mowed + fall graze suppressed sod. Uneven surfaces due to tillage or black surface caused by burning may have provided unfavorable characteristics that caused poorer emergence or seedling death in the field cultivate/disk or burn treatments compared to graze or herbicide treatments. It is unclear why the frequency of occurrence of legumes in the herbicide treatment was similar to no sod suppression in Experiment I and II. Cuomo et al. (2001) reported legume stands of < 1% without herbicide sod suppression. Favorable precipitation in 2004 may have benefited the legumes in the no sod suppression plots. Another explanation may be the timing of when stand counts were taken. In this study, stand counts were made mid-summer approximately 2 months after seeding whereas Cuomo et al. (2001) reported stand counts in the fall during the year of establishment.

A better measure of stand establishment success comes from the frequency of occurrence of legumes measured one year after establishment. In Experiment I, only the fall and spring graze treatment had a frequency of occurrence near that of an acceptable stand (≥ 1 plant per ft^2; Table 2). None of the other sod suppression treatments had greater frequency of occurrence of legumes than no sod suppression.

In Experiment II, fall and spring graze, herbicide, and burn sod suppression treatments had the greatest frequency of occurrence of legumes a year later (Table 2). The other treatments were similar to no sod suppression, but produced acceptable stands.

Species

In Experiment I, alfalfa had a higher (P< 0.01) frequency of occurrence during the year of establishment than birdsfoot trefoil or kura clover (Table 3). Similar to the findings of Cuomo et al. (2001), kura clover had the least (P< 0.01) frequency occurrence, probably a result of poor seedling vigor (Lucas et al., 1980; Scott, 1985). In Experiment II, birdsfoot trefoil had a higher (P< 0.01) frequency of occurrence during the establishment year than alfalfa. We attribute these differences to precipitation during the year of establishment (Table 1). Alfalfa is known for its drought tolerance and need for well drained soils (Barnes and Sheaffer, 1995). During Experiment II, precipitation in May was twice that of Experiment I, which could have resulted in wetter conditions more favorable for birdsfoot trefoil seedlings (Beuselinck and Grant, 1995). Frequency of occurrence the year after establishment was greatest for alfalfa in Experiment I and greatest for birdsfoot trefoil in Experiment II (Table 3). In Experiment I, stand counts one year after establishment were less than reported by Cuomo et al. (2001) for the same species. In Experiment II, birdsfoot trefoil stands were greater than those reported by Cuomo et al. (2001), which we attributed to favorable moisture conditions.

Costs and Management

Costs of sod suppression treatments were estimated from various sources. Burn treatment was estimated at $2 per acre from Ortman et al. (1996). Cost of tillage operation (field cultivate or disk) was estimated at $4.60 per acre (Lazarus and Selley, 2004). Herbicide cost was estimated at $13.30 per acre from an herbicide price list by Wrage et al. (2002), including a custom application fee of $6.50 per acre (Volga Coop, personal communication). Cost of heavy fall and spring graze was $0 per acre, because it was assumed that fencing and water would be in place and rotation of cattle to pastures would be part of the overall grazing system for an operation.

Clearly, from a cost savings perspective, heavy fall and spring grazing was the least expensive followed by burning, tillage, and herbicide. From a management standpoint, burning requires a familiarity and a level of comfort to be able to use as a sod suppression technique. The window of opportunity can be narrow because certain environmental conditions have to be favorable to allow for a burn (Masters et al., 1990). A burn permit may be required which takes additional time to obtain.

Heavy fall and spring grazing requires a high stock density and monitoring efforts from the manager to achieve defoliation of vegetation of <2 in. stubble height. For example, in our study stocking rates ranged from 28 to 78 AUD per acre (approximately 20 to 55 cows weighing 1400 lb grazing one acre for one day) to achieve the desired level of defoliation in the fall and spring. There could be a loss of animal performance in order to achieve this level of defoliation because quantity of forage may be inadequate as stubble height decreases. If the size of the pasture renovation project is quite large (> 80 acres) it could take considerably more animals or a longer grazing period to achieve the desired level of defoliation. Minimizing the time it takes to achieve the desired defoliation will minimize any loss in animal performance.

Tillage using a disk or field cultivator is relatively risk free and management issues are few. Both implements are readily available. Excessive precipitation in the spring or conflicts with other farming operations are most likely timing issues associated with tillage. Management issues to consider for herbicide are timing of application and correct rates. Whether done by the operator or hired by custom applicator, these issues are not trivial. If herbicide application is too early, the effective window of sod suppression may be shortened and could result in poor stand establishment. If the application of herbicide is too late, it could kill emerging legume seedlings. The correct herbicide rate is critical in providing a long window of sod suppression for legume establishment, but not carrying over into the next year and thereby potentially reducing forage production. All of these sod suppression techniques are designed to reduce the competition of existing grass to allow the legume seedling a chance to establish. Increased weeds and reduced yield can be negative carryover effects of sod suppression a year after application. In Experiment I, heavy fall and spring graze was the only treatment to significantly (P = 0.10) reduce forage yield one year following establishment (Table 4). However, in Experiment II there was no reduction in biomass from sod suppression treatments. Seguin et al. (2001) showed mixed results of herbicide reducing herbage yield one year after establishment, however grazing did not reduce herbage yield. If pasture yield is a concern, providing a spring or fall grazing deferment may improve plant vigor enough to restore the pasture's productivity.

Implications

Sod suppression techniques enhance the success of legume interseeding. Burn-down herbicides are commonly recommended to control the competition from the existing grass sod for legumes seedlings to establish. We showed that alternative physical techniques such as spring burning, field cultivating or disking, and heavy fall and spring grazing are also effective. In this study the performance of sod suppression techniques such as grazing equaled or were better than herbicide. Costs of such treatments vary from $0 per acre (grazing) to $13.30 per acre (herbicide). Management of sod suppression treatments is important to provide a long enough window for legumes to establish with minimal competition from existing grass. Managers can choose the sod suppression technique and legume that fits their resources, skills, and comfort level to achieve successful legume interseeding.

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Tables

Table 1. Average maximum monthly temperature and monthly precipitation for May through September for Brookings, SD.

Month	Year 2003	Year 2004	30-yr mean
	Mean Maximum Temperature		
	------------ °F ----------------		
May	65	65	68
June	75	73	77
July	82	79	82
Aug.	83	70	79
Sep.	75	75	71
	Precipitation		
	----------- inches ---------------		
May	2.7	6.2	2.9
June	3.3	2.7	4.3
July	2.8	4.4	3.2
Aug.	2.2	0.9	3.0
Sep.	3.5	6.2	2.7
Annual	18.7	25.0	23.2

Table 2. Frequency of occurrence of interseeded legumes into smooth bromegrass/Kentucky bluegrass pasture using sod suppression treatments near Brookings, SD.

	Establishment year		Year after establishment	
Sod suppression	Experiment I	Experiment II	Experiment I	Experiment II
	-------------------- Frequency of occurrence %	--------------------		
Burn	45[c]	53[c]	10[b]	48[ab]
Field cultivate/disk	55[b]	55[bc]	6[b]	32[b]
Fall and spring graze	64[a]	76[a]	23[a]	60[a]
Herbicide	39[cd]	75[a]	5[b]	62[a]
No suppression	38[d]	68[ab]	<1[b]	24[b]
LSD (0.05)	13.9	13.6	10.8	24.6

[a, b ,c ,d] Means within a column followed by similar letters are not statistically different ($P < 0.05$).

Table 3. Frequency of occurrence of alfalfa, birdsfoot trefoil, and kura clover interseeded into smooth bromegrass/Kentucky bluegrass pasture averaged over sod suppression treatments near Brookings, SD

	Establishment year		Year after establishment	
Species	Experiment I	Experiment II	Experiment I	Experiment II
	-------------------- Frequency of occurrence %	--------------------		
Alfalfa	77[a]	55[b]	22[a]	38[b]
Birdsfoot trefoil	54[b]	75[a]	5[b]	52[a]
Kura clover	13[c]		<1[b]	
LSD (0.05)	6.2	8.4	8.1	8.5

[a, b ,c ,d] Means within a column followed by similar letters are not statistically different ($P < 0.05$).

Table 4. Herbage biomass one year after establishment in Experiment I (4 June 2004) and Experiment II (11 July 2005) near Brookings, SD.

Sod suppression	Experiment I	Experiment II
	---------- lb per acre	----------
Burn	2090[ab]	4180
Field cultivate/disk	2140[ab]	3840
Fall and spring graze	1810[b]	4080
Herbicide	2290[ab]	3930
No suppression	2460[a]	3720
LSD (0.05)	480	725

[a, b] Means within a column followed by similar letters are not statistically different ($P < 0.05$).