Effectiveness and Economics of Native Pasture Restoration Practices Designed for the Southern Great Plains

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ABSTRACT: In the southern Great Plains pastures of nativegrass mixtures have been shown to provide early season forage and contain grasses that vary in seasonal forage distribution providing higher quality forage further into the growing season than monocultures such as switchgrass (*Panicum virgatum*). Compared to improved pastures of bermudagrass (*Cynodon dactylon*), nativegrass mixtures increase wildlife habitat, lower maintenance cost, and can improve land value. These benefits have increased interest in conversion of improved pasture land areas to nativegrass pastures. Because of its herbicide tolerance, ability to propagate from stolons, rhizomes, and seed, bermudagrass is difficult to control making conversion challenging. To be successful, conversion methods need to be acquired. A two-year, two location conversion study was developed to determine efficacy and economics of twelve conversion systems for bermudagrass control and establishment of a nativegrass mixture of little bluestem (*Schizachyrium acoparium* 'Cimarron'), big bluestem (*Andropogon gerardii* 'Kaw'), indiangrass (*Sorghastrum nutans* 'common'), switchgrass ('Alamo'), and green sprangletop (*Leptochloa dubia* 'common'). Conversion systems consisted of combinations of preparation time (7, 11, 19 months from treatment initiation to planting), cover crops (0, 1, 2, 3), glyphosate application (6, 8, 10 qts/ac) (13.8, 18.4, 23 L ha^{-1}) and tillage (conventional till, no-till). Nativegrass planting date for all conversion systems was April. Tillage systems were more effective than no-tillage. Mean yields across locations and years for no-till were 858 lb/ac and 2868 lb/ac compared to tillage yields of 2243 lb/ac and 6637 lb/ac for nativegrass and switchgrass respectively. Tillage systems with cover crops (2 or 3) and preparation time (11 or 19 months) were more successful in establishing nativegrass but had little effect on switchgrass establishment. For the base-case threshold measure of success (>=70% of total stand), the clean till system with three cover crops was most economical at the Burneyville, Oklahoma, location, realizing a $208 net return per acre. At the Ardmore, Oklahoma, location, systems established with clean-till and no-till methods with both 2 and 3 cover crops were equally more profitable than systems that utilized chemical fallow methods. Systems that utilized chemical fallow methods did not realize positive net returns, but did meet the minimum threshold of success requirement of at least 70% of total NG stand. Relative net returns between systems were most sensitive to prices of rye and sorghum-sudan hay.

Keywords: bermudagrass, economics, native pasture restoration

Bermudagrass is a common introduced warm-season perennial forage grass in the southern Great Plains. It is widely grown due to its persistence under grazing pressure, tolerance to drought and it responds well to fertilizer inputs. Bermudagrass can vegetatively reproduce through rhizomes and stolons and this makes it a very aggressive competitor and difficult to control or eradicate once it becomes established. These aggressive and competitive characteristics make bermudagrass difficult to grow with other forage species such as legumes in the southern plains environment. Therefore, bermudagrass is often grown as a monoculture which tends to maximize its production efficiency but, diminishes its suitability for wildlife habitat. To obtain this production efficiency, nitrogen fertilizer is applied at rates dependent upon yield goals and phosphorus, potassium and soil pH levels need to be maintained at soil test levels that will not limit yield which, is a yearly cost to the producer. In recent years, establishing nativegrass into areas occupied with bermudagrass has increased in interest because of wildlife benefits, improved land value due to the improvement in wildlife habitat, and lowered land maintenance cost as native range areas are typically not weed sprayed or fertilized. Switchgrass, a native warm-season perennial grass, can produce grazeable forage earlier in the growing season than bermudagrass. This early forage production is high in nutritive value and can produce good stocker cattle gains into early summer. Switchgrass is typically fertilized at lower nitrogen rates than bermudagrass which reduces its maintenance cost. As part of a grazing system switchgrass has shown good potential due to its early season nutritive value and production.

For landowners that desire to convert existing bermudagrass to nativegrass to increase diversity and improve wildlife habitat, suppressing and controlling the bermudagrass is challenging. The objectives of this study were to evaluate the effectiveness and economics of twelve systems designed to convert existing bermudagrass to a mixture of nativegrasses and to determine how sensitive the results are to changes in prices of hay and glyphosate.

Materials and Methods

Agronomic

A plot study consisting of two planting years (April, 2011 and April, 2012) at two locations was developed to evaluate the effectiveness of twelve systems (Table 1) to suppress or control bermudagrass (BG) prior to the establishment of nativegrass (NG) made up of: ‘Cimarron’ little bluestem, ‘Kaw’ big bluestem, ‘common’ indiangrass, ‘Alamo’ switchgrass, and ‘common’ green sprangletop.

Both study locations were in established common bermudagrass in excess of 10 years. Location 1 (HQ) was located at the Noble Foundation’s Headquarters farm in Carter County, Oklahoma on a loamy fine sand. Results of a 0-6 inch depth soil test taken prior to the initiation of the study had a pH of 5.5, 14 lb/ac available phosphorus, and 160 lb/ac available potassium. Previous BG management at the HQ location is unknown. Location 2 (RR) was located at the Noble Foundation’s Red River Research and Demonstration Farm in Love County, Oklahoma on a fine sandy loam. Soil test results at the 0-6 inch depth at this location had a pH of 5.6, an available phosphorus level of 66 lb/ac and available potassium of 133 lb/ac. The RR location had previously been in hay production prior to the beginning of the study.

For each planting year of the study and at each location, a plot area of 100’ x 115’ was prepared. The plot area was subdivided into 36 - 12’ x 20’ plots with 5’ alleys between plots. Total plot area (36 plots) was randomly assigned to NG establishment. The BG control treatments were a factorial design arranged into complete blocks with three replications (12 plots per replication) and consisting of two tillage types; till or no-till (NT) with combinations of 0, 1, 2 or 3 cover crops (rye or sorghum-sudan) and 7, 11, or 19 months of time spanning initiation preparation time for each system. Preparation time was the amount of time spent suppressing the BG from the start of the study to the NG planting date. A time table of the activities for each conversion system is presented in Table 1.

The starting dates for the conversion systems were staggered according to the preparation time length (Table 1). The HB7NT and HB7CT, CC1NT and CC1CT systems had a 7 month preparation time began in September 2010 (year 1) and September 2011 (year 2). Systems HB11NT, HB11CT, CC2NT, and CC2CT had an 11 month preparation time beginning in May, 2010 (year 1) and May, 2011 (year 2). Systems HB19NT, HB19CT, CC3NT and CC3CT had a 19 month preparation time beginning in September, 2009 (year 1) and September, 2012 (year 2). Regardless of the starting time, all conversion systems shared a common NG planting in April in their respective planting year.

At the start date for all conversion systems, a 4 qt/ac rate of glyphosate (Gly) was applied to the BG. Additional applications of gly at a rate of 2 qt/ac were applied prior to planting each cover crop and prior to planting NG. The total amount of gly applied varied by system. The HB7NT and HB7CT, CC1NT and CC1CT systems received 2 gly applications and a total amount of 6 qt/ac; systems HB11NT, HB11CT, CC2NT, and CC2CT received 3 gly applications and a total of 8 qt/ac; and systems HB19NT, HB19CT, CC3NT and CC3CT received 4 gly applications and a total of 10 qt/ac;

Cover crops were established either no-till (NT) or with conventional tillage (CT) according to their treatment number (Table 1). For CC1NT and CC1CT the cover crop was cereal rye (rye). Systems CC2NT and CC2CT had two cover crops: sorghum-sudan (SS) followed by rye. Systems CC3NT and CC3CT had three cover crops: rye followed by SS followed by rye. Nitrogen, phosphorus and potassium were applied to cover crops according to soil test levels at rates high enough that deficiencies of those elements would be unlikely to limit yield. For the HQ location this was usually 62-62-62 lb/ac for both rye and SS cover crops while at the RR location, 62-0-0 lb/ac would be used for both cover crops.

Cover crops were harvested and yield and nutritive values determined (data not presented). Conventional tillage (CT) was done using a tractor powered roto-tiller followed by culti-packing and seeding. Cover crops established using CT were planted with a Hege 500 plot drill while NT cover crops were planted using a Hege 1000 plot drill. The seeding rate for rye cover crop was 100 lb/ac and SS was 27 lb/ac.

NG plantings occurred in April, 2011 (year 1), and April, 2012 (year 2). NG plots were established using a Great Plains 705 drill. The NG seeding rate was 10 lb/ac bulk, and SG was 9.0 lb/ac bulk. NG were both planted at a 0.25-0.50 inch depth. All drills were calibrated prior to use. Weed control was not required in the cover crops. In NG plots, broadleaf weeds were controlled using 1 qt/ac of 2, 4-D applied as needed but only after NG had reached a 3-4 leaf stage.

Planting year 1 (April 2011) plots were harvested in March 2013, and March 2014, and planting year 2 (April 2012) plots were harvested in March 2014 and March 2015. Plots were harvested using a 0.25-m^2 frame that was dropped 4 times within each plot for a total of 1-m^2 harvest area. Plot harvest samples were hand separated by component (switchgrass or mixed native grasses) and weed (mainly BG, annual grasses and forbs), then air dried at 140^0F to constant weight for dry matter and forage mass determination.

NG and weed yields were analyzed by location using the PROC MIXED procedure of SAS, Version 9.3 (SAS Institute, Cary, NC). Planting year and replication were treated as random effects and conversion system as a fixed effect. LSMEANS with the pdiff option were generated for treatment means and differences between LSMEANS were declared significant at $P \leq 0.05$. Data are presented by location and harvest year.

Economic

Enterprise budgeting techniques were used to estimate expected values for costs, revenue, and net return for all seven systems (AAEA, 2000). Budgets for all 12 systems included costs of establishing nativegrass mixtures and annual maintenance for all seven systems. Establishment costs included costs of seedbed preparation using a disc and a cultivator, costs of herbicide (glyphosate and 2,4-D Amine) and its application, costs of seed and seed establishment and cost of mowing operation. Estimated stand life for switchgrass was assumed to be 10 years. Therefore, the estimated total cost of establishing switchgrass stands was amortized over 10 years at a 7.5% annual rate.

Cost of annual maintenance activities of all seven systems included N fertilizer and fertilizer application, herbicide (2,4-D Amine) and herbicide application, harvesting activity, and annual operating interest. Cost of harvest activities (mowing, raking, baling into large (561 kg) round bales and hauling and stacking) were included in the annual budget for the no-graze feedstock only (NG/F) and for three graze plus feedstock systems (GL/F, GM/F and GH/F). In addition, cost of mowing was included only in the budget for the three graze-only systems. Cost of mowing and raking does not vary between systems as it is estimated on ha-1 basis; however, the cost of baling and hauling and stacking varies between systems as it is a function of yield [10, 25]. Cost of steer interest (opportunity cost of owning cattle during the grazing period) was included for the three graze-only and three graze plus feedstock systems.

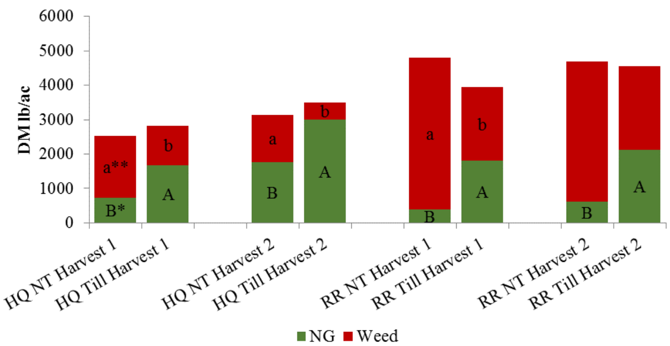
Custom rates were used to estimate costs associated with machinery operations for establishment activities [disking ($29.65 ha-1), cultivating ($18.53 ha-1), seed planting ($32.12 ha-1), mowing switchgrass stands ($34.59 ha-1)] and for harvest activities [mowing switchgrass in baling process ($24.98 ha-1), raking ($9.59 ha-1), bailing ($36.18 ha-1), hauling and stacking ($11.12 ha-1). A rate of $14.83 ha-1 was used for fertilizer and herbicide applications. Custom rates were obtained from Oklahoma Cooperative Extension Service [26]. Retail prices of $1.21 kg-1 of N (urea, 46-0-0), $33.07 kg-1 for switchgrass seed, $3.95 L-1 for herbicide glyphosate and $5.03 L-1 for herbicide 2,4-D Amine were obtained from local farm input suppliers.

Results

Agronomic

The effect of tillage significantly increased harvest 1 and 2 yields of NG at both locations (Fig. 1).

Figure 1. Harvest year 1 and 2 harvest means of tillage effect on NG and weed yields at two locations.



*Upper case letters that differ within location and harvest are significantly different at P < 0.05.

**Lower case letters that differ within location and harvest are significantly different at P < 0.05.

The weed component was greater than 50% of the total harvest 1 yields from the NT treatments at both locations (Fig. 1). Yields of NG from NT treatments improved greatly at the HQ location by harvest 2 but only slightly at the RR location. At the HQ location, NG yields for the till treatment were greater than 50% of the total yield for harvest 1 and 2 but slightly below 50% for both harvest at the RR location (Fig. 1). Weed pressure, which was mostly BG, was much higher at the RR location reducing NG yields.

Treatment 1, which was the shortest preparation time tended to have lower NG yields at HQ (Fig. 3) and RR (Fig. 4) than the other treatments.

Figure 3. NG harvest 1 means by tillage treatment at HQ compared to the no-till mean

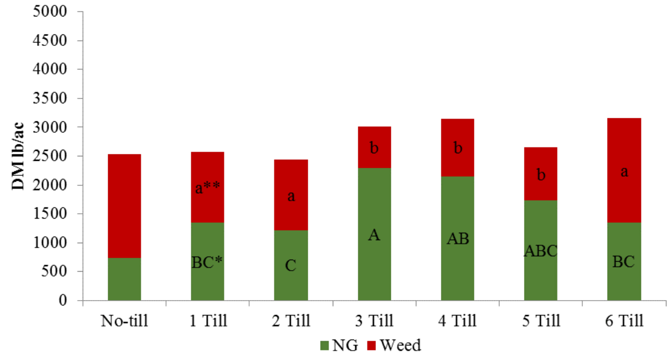
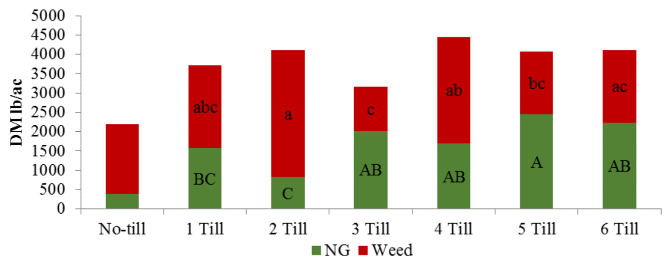


Figure 4. NG harvest 1 means by tillage treatment at RR compared to the no-till mean



*NG treatment yields with different upper case letters are significantly different at P < 0.05.

**Weed yields with different lower case letters are significantly different at P < 0.05.

Comparing NG means of treatments with a cover crop to treatments without a cover crop but with the same preparation time (1 vs 2, 3 vs 4, 5 vs 6) there is no statistical increase in NG yield by use of a cover crop. It is noted however, that at each location, treatments with a cover crop did have higher numerical NG yields compared to the sister treatments that did not.

Figure 5. NG harvest 2 means by tillage treatment at HQ compared to the no-till mean

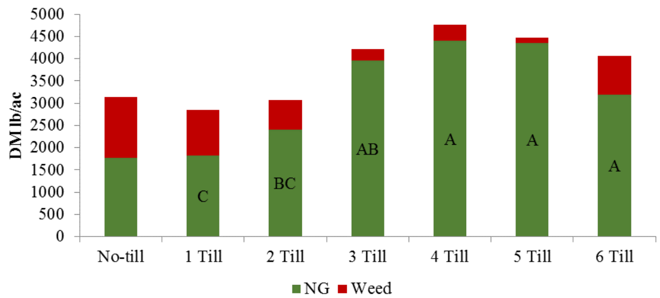
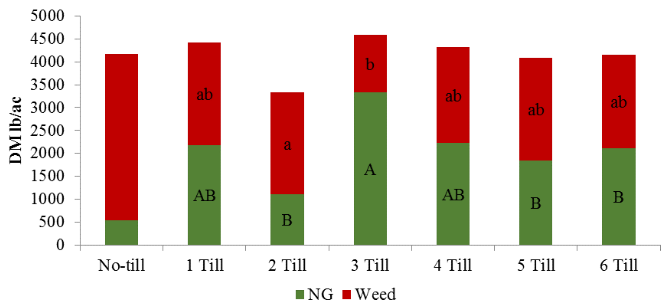


Figure 6. NG harvest 2 means by tillage treatment at RR compared to the no-till mean



*NG treatment yields with different upper case letters are significantly different at P < 0.05.

**Weed yields with different lower case letters are significantly different at P < 0.05.

NG yields increased from harvest 1 to harvest 2 at both locations (Figs. 5 and 6). At the HQ location, NG yields tended to be higher from treatments (3-6) that involved a longer preparation time than the shorter 7-month preparation time (Fig. 5). Weed pressure at the HQ location decreased substantially from harvest 1 to harvest 2 but, remained high at the RR location. At the RR location, previous BG management had been for hay production and soil test nutrient levels were higher at this location compared to HQ. This resulted in more aggressive weed competition at RR. As in harvest 1, there was no statistical cover crop effect on harvest 2 yields (Fig. 6).

Economic

Conclusions

In this study, conversion systems that utilized conventional tillage methods were more successful in terms of yield in the establishment of cover crops and NG compared to the systems that utilized no-till establishment practices. Tillage did increase the suppression of bermudagrass allowing NG to establish. At least two factors could have influenced the poor performance of no-till compared to tillage methods. The first being the failure to completely control bermudagrass chemically. If bermudagrass plants within a plot escaped chemical control, they quickly spread and competed with establishing seedlings. Since there was no way to suppress bermudagrass competition once NG emerged, the bermudagrass could aggressively compete with the new seedlings. A second reason was likely poor seed to soil contact with no-till and an issue with controlling seed depth. In no-till plots a very deep thatch layer developed after chemical treatment of the bermudagrass. This could have then created seed placement issues with seed being placed on top of the thatch layer or in the thatch layer which could then influence germination and emergence. These issues concerning no-till establishment need to be addressed with additional research as tillage establishment may not always be a viable alternative in some areas due to erosion potential from tillage.

Incorporating a cover crop into a tillage conversion system had no effect on harvest 1 yields. The cover crops that were used in this study were harvested and removed as hay, they were not grazed or incorporated back into the system. Had they not been removed from the system, the effect of the cover crop might have been different and this effect should be tested in a future experiment. Conversion systems with longer preparation time (11 or 19 months) did appear to improve NG establishment compared to the 7 month preparation time.

No-till establishment of these grasses should not be completely disregarded. While yields of NG were greater for systems that used conventional tillage methods, yields from no-till treatments did improve over time. It should also be noted that while no-till yields were lower, no-till systems did improve the plant diversity which would have an impact on wildlife habitat.

A cover crop can be planted for the fall and winter if soil erosion is a concern. If a producer is wanting to convert bermudagrass to NG the recommended system would be the longer preparation time systems (HB19NT, HB19CT, CC3NT and CC3CT). While the use of cover crops with these systems would not improve establishment success, they should be considered if soil erosion is a concern. If the cover crops could be grazed or harvested in some way, they could then help to offset the establishment costs of the long preparation time treatments.

Establishment of SG was more successful than the establishment of NG and by harvest 2 SG stands were nearly fully developed with little weed competition. NG stands were much slower to develop but by harvest 2 NG yields had improved and weed pressure was lower indicating that if managed for the NG component that over time the NG stand would be expected to continue to improve.

Table 1. Production activities by month and production year (PY) by conversion system

System	Sept., PY1	April, PY1	May, PY1	Sept., PY2	April, PY2	June., PY3
HB22NT				Gly. BG	Gly. BG, NT est. NG	Har. NG as Hay
HB22CT				Gly. BG, CT	Gly. BG, CT est. NG	Har. NG as Hay
HB26NT			Gly. BG	Gly. BG	Gly. BG, NT est. NG	Har. NG as Hay
HB26CT			Gly. BG, CT	Gly. BG, CT	Gly. BG, CT est. NG	Har. NG as Hay
HB34NT	Gly. BG	Gly. BG		Gly. BG	Gly. BG, NT est. NG	Har. NG as Hay
HB34CT	Gly. BG, CT	Gly. BG, CT		Gly. BG, CT	Gly. BG, CT est. NG	Har. NG as Hay
CC1NT				Gly. BG, NT est. rye	Har. rye hay, Gly, NT est. NG	Har. NG as Hay
CC1CT				Gly BG, CT est. rye	Har. rye hay, Gly, CT est. NG	Har. NG as Hay
CC2NT			Gly. BG, NT est/ Sorg. S.	Har. Sorg. S., Gly., NT est. rye	Har. rye hay, Gly, NT est. NG	Har. NG as Hay
CC2CT			Gly. BG, CT est. Sorg. S.	Har. Sorg. S., Gly, CT est. rye	Har. rye hay, Gly, CT est. NG	Har. NG as Hay
CC3NT	Gly. BG, NT est. rye	Harv. rye as hay, Gly., NT est. Sorg. S.		Har. Sorg. S., Gly., NT est. rye	Har. rye hay, Gly, NT est. NG	Har. NG as Hay
CC3CT	Gly. BG, CT est. rye	Har. rye as hay, Gly., CT est. Sorg. S.		Har. Sorg. S., Gly., CT est. rye	Har. rye hay, Gly, CT est. NG	Har. NG as Hay

Table 2. Efficiency, yields and Economics by Conversion System at Burneyville

System	Percent of total stand >70%	Yield CC1 lbs/acre	Yield CC2 lbs/acre	Yield CC3 lbs/acre	Net* Return $/acre	Net** Return $/acre
CC3CT	0.75	2755	12331.33	6327.17	222.80	207.80

* net return assuming that landowners would rent native range for grazing at $15/acre/year
**net return assuming that landowners would not rent native grass pasture for grazing.

Table 3. Efficiency, yields and Economics by Conversion System at Ardmore

System	Percent of total stand >70%	Yield CC1 lbs/acre	Yield CC2 lbs/acre	Yield CC3 lbs/acre	Net* Return $/acre	Net** Return $/acre
CC2CT	0.96	-	7322.5	7943.17	159.69	144.69
CC2NT	0.71	-	7614.33	6538.5	154.11	139.11
CC3CT	0.88	2912.83	8740.17	7414.67	146.28	131.28
CC3NT	0.78	4008.83	6405.17	6554	117.38	102.38
HB32CT	0.78	-	-	-	-3.41	-18.41
HB34CT	0.77	-	-	-	-3.41	-18.41
HB42CT	0.90	-	-	-	-3.41	-18.41
P-value	--	0.0037	0.0187	0.0241	0.0025	0.0025

* net return assuming that landowners would rent native range for grazing at $15/acre/year
**net return assuming that landowners would not rent native grass pasture for grazing.