Overseeding Bermudagrass Pastures with Ryegrass and Clovers: Estimating Partial Returns

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ABSTRACT

Results from a three-year study at University of Arkansas' Southeast Research and Extension Center in Monticello, Arkansas were used to examine partial returns (PR) from stocker cattle grazing bermudagrass pastures overseeded with ryegrass and crimson clover, white clover, or crimson and white clover in two grazing seasons. The study revealed that at current fertilizer and seed prices, the control pasture, overseeded with ryegrass and fertilized with commercial nitrogen, provided higher PR than pastures overseeded with clovers and ryegrass. Furthermore, the study revealed current nitrogen fertilizer prices would have to more than double for producers to achieve greater PR with clovers.

Introduction

Rising fertilizer prices and increased concerns over nutrient runoff have necessitated additional region-specific research on the economics of nitrogen-fixing, legume-based forage management strategies.






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Over the past 10 years nitrogen (N) fertilizer has more than tripled in price (USDA-ERS, 2012), which has eroded cattle and forage producer profits and created the need for further examination of alternative forage systems that include nitrogen fixing legumes. As such, the objective of this study was to examine differences in estimated producer returns for bermudagrass pastures overseeded with different clover-ryegrass combinations by examining changes in animal performance, tracked via average daily gain, and forage production.

Improving pastures with nitrogen-fixing legumes has the potential to reduce fertilizer costs, improve forage quality for cow-calf and stocker enterprises, and distribute forage production more evenly throughout the grazing season (Knight, 1970; Evers, 1985). Clovers have been estimated to provide 50 to 250 lbs./acre of N through fixation of atmospheric nitrogen (N_2) by rhizobia bacteria in root nodules (West & Mallarino, 1996; UACES, 2012). Overseeding clovers in bermudagrass [*Cynodon dactylon* (L.) Pers.] pastures was estimated by Overman et al. (1992) to replace up to 107 lbs./acre of N fertilizer. Clovers are also higher in crude protein and offer greater digestibility than other forages common to southern Arkansas pastures, making them an attractive alternative forage for cattle producers. Cattle weight gains on bermudgrass pastures overseeded with clovers were equal to those of ryegrass overseeded in bermudagrass fertilized with 150 lbs./acre of N (Hoveland et al., 1978). Additionally, adding clovers to the forage species mix has the ability to extend the grazing season by as much as three months as clover growth in the spring occurs when bermudagrass is dormant (West & Waller, 2007; Hoveland et al., 1978). Overseeding pastures with ryegrass [Lolium multiflorum (L).] and clovers provides high quality forage to cow-calf producers from February to April when nutritional needs for January-February calving cows are greater.

Agronomic and animal performance advantages of overseeding bermudgrass pastures with ryegrass and clover are well established, however, forage producers in the southeastern United States require additional empirical research as to the potential differences in net returns and sensitivity to input prices as empirical research results are mixed. For example, Biermacher et al. (2012) found net returns to land, labor, management, and overhead for bermudagrass pastures in south-central Oklahoma inter-seeded with hairy vetch (*Vicia villosa*) and crimson clover (*Trifolium incarnatum*), alfalfa (*Medicago sativa*), and with standard commercial N application to be: $52.62, $34.96, and $85.66 per acre, respectively. Profitability was most sensitive to N price, price of legume seed, and number of grazing days. On the other hand, Butler et al. (2012) found no significant difference in expected net returns for rye/annual ryegrass pastures fertilized with commercial N or seeded with a legume mixture [arrowleaf clover (Trifolium vesiculosum), field pea (Pisum sativum), and hairy vetch] in south-central Oklahoma.

A three-year study conducted at the University of Arkansas Southeast Research and Extension Center in Monticello, AR (91°48’W; 33°35’N) from 2009 to 2011 estimated the impact of overseeding bermudagrass pastures with ryegrass (cultivar:

'Marshall'), crimson clover (cultivar: 'Dixie') and white clover (*Trifolium repens*; cultivar: 'Osceola'). Four pasture treatments were established: i) bermudagrass overseeded with ryegrass using commercial N-fertilizer (*Conv*); ii) bermudagrass overseeded with ryegrass, crimson, and white clover (*CW*); iii) bermudagrass overseeded with ryegrass and crimson clover (*C*); and iv) bermudagrass overseeded with ryegrass and white clover (*W*). Using partial budgeting, changes in producer net returns were estimated for each treatment. Since these changes in net returns do not account for all costs and revenues, they are termed partial returns in this analysis and account only for those costs and revenue streams that did change across treatments. As such, this analysis breaks down partial return implications for hay, fertilizer, and seed cost as well as cattle and hay revenue. Further, breakeven prices for N fertilizer are also calculated to determine at what commercial N fertilizer price the practice of nitrogen-fixing clovers becomes a profitable alternative for producers grazing stockers in the spring and summer seasons.

Materials and Methods

Study Background and Design

Soils at the University of Arkansas Southeast Research and Extension Center pasture site were classified as an Amy Silt loam (fine-silty, siliceous, semiactive, thermic Typic Endoaquults), a Sacul (fine, mixed, active, thermic Aquic Hapludults), and a Tippah silt loam (fine-silty, mixed, active, thermic Aquic Paleudalfs) with slopes of up to three percent (USDA-NRCS, 2012). The area has an annual mean precipitation of approximately 55.4 inches and an average air temperature of 62.1°F (NOAA, 2012). These conditions are deemed representative of many pasture conditions typical of a cow-calf operation in southeastern Arkansas. The experimental pastures consisted of established common bermudagrass and were randomly selected for overseeding with ryegrass as the control and two pastures each of either crimson clover, white clover, or both. Prior to broadcast seeding, at the middle of September of each year, pastures were disked lightly. After seeding, pastures were smoothed using a 10-foot chain harrow to improve soil-to-seed contact. Irrespective of treatment, seeding rates were 30 pounds per acre of ryegrass seed, 10 pounds per acre pure live seed (PLS) of crimson clover and 6.5 pounds per acre PLS for white clover. Seeding rates for white and crimson clover were held constant for each species to fully represent its respective grazing period. Seeding occurred in the fall of each year over the course of each of the three years of the experiment.

Clover and *Conv* treatments received different amounts of fertilizer (summarized in Table 1) to highlight the differences in animal performance. In November of 2008, the *Conv* treatments received 300 pounds per acre of 19-19-19 (57 lbs./acre of actual N, P, and K). In addition, clover treatments received 200 pounds per acre of 0-23-30. In February of the following year, *Conv* treatments received 150 pounds per acre of 34-0-0 (51 lbs./acre of actual N) whereas pastures with clovers only received 60 pounds of 34-0-0 (21 lbs. of N/acre). Fertilization of legume treated pastures was performed to allow for the same starting date for grazing across all treatments as ryegrass development would have been delayed without spring fertilization and hence treatment comparisons compromised. The fertilizer quantities applied were considered large enough to initiate ryegrass production and yet small enough to not limit N fixation rates in clover treatments. The *Conv* treatments were fertilized again in June 2009 with 150 pounds per acre of 34-0-0 (51 lbs./acre actual N).

In November of 2009, *Conv* treatments received 300 pounds per acre of 19-19-19 (57 lbs./acre of actual N). Clover treatments received 300 pounds per acre of 6-24-24 (18 lbs./acre actual N) the same day. In March of 2010, *Conv* treatments received 180 pounds per acre ammonium nitrate (61 lbs./acre actual N), and clover treatments received 100 pounds per acre ammonium nitrate (34 lbs./acre actual N). A quantity of 1.5 tons per acre of lime was also applied in 2009 to all treatments. During November of 2010, pastures received the same amounts of fertilizer that were applied the previous autumn. During spring of 2011, none of the pastures received fertilizer.

Different groups of newly weaned calves were used for spring and summer grazing. Animals were moved onto pastures at the beginning of spring and summer when clovers reached a height of at least three inches, on average. For spring grazing in 2009, Gelbvieh × Angus crossbred spring-born heifers (n = 40; 686 ± 9.7 lbs. initial body weight) from the University of Arkansas Livestock and Forestry Research Station near Batesville, Arkansas were used and shipped to the University of Arkansas Southeast Research and Extension Center in Monticello, Arkansas. Heifers (n = 40) remained as a group upon arrival at the University of Arkansas Southeast Research and Extension Center and were placed on a dormant common bermudagrass pasture and given bermudagrass hay ad libitum until they were assigned to pastures. The groups were stratified by body weight and assigned randomly to one of the eight, approximately five-acre pastures (two pastures per treatment) which were divided into two equally-sized grazing cells using temporary electric fencing. Animals were rotated between cells every 14 days after initiation of grazing and weighed every 28 days regardless of treatment. During the first year of the study, cattle were placed on *Conv* pastures January 23, 2009. However, grazing on clover treatment pastures was not initiated until March 6, 2009 due to a lack of available forage. Heifers remained on their respective pastures until May 11, 2009. Remaining forage biomass and regrowth was cut for hay on May 27, 2009. For summer grazing during 2009, Beefmaster or Beefmaster × Angus crossbred heifers were obtained from a commercial cattle producer (n = 64; 646 ± 5.3 lbs. initial body weight) and added to the pastures on June 22, 2009 for the summer grazing. Pastures and rotations were managed the same as in spring. For all treatments, cattle were removed from the pastures August 27, 2009. No cattle were placed on the pastures in the fall to allow for the annual plantings of ryegrass and clovers as dictated by treatment and as growth would be stockpiled for the following spring grazing season.

For the second year of study, the randomization structure of treatments remained the same to allow us to monitor possible carryover effects of treatments. Heifers were again rotated between cells and weighed at the same intervals used in the first year. Heifers from Batesville (n = 40; 534 ± 10.4 lbs. initial body weight) were stocked on their respective pastures on March 15, 2010 when forage biomass was great enough to begin grazing on all treatments. Nonetheless, in 2010, grazing days were possibly affected across all pastures due to heavy damage by grazing wildlife early in 2010. Cattle remained on their respective pastures until May 12, 2010. The remaining forage biomass was cut for hay May 19, 2010. Beefmaster or Beefmaster × Angus crossbred heifers and steers (n = 64; 553 ± 11.0 lbs. initial body weight) from the University of Arkansas Southeast Research and Extension Center herd were added to the pastures on July 7, 2010 for the summer portion of the trial. The pastures and rotations were managed the same in summer as they were in spring. Cattle were removed from the pastures August 31, 2010.

During the final year of the study, cattle were obtained from the same sources as in year two and grazing management of treatments remained the same. Spring grazing of heifers (n = 40; 520 ± 12.1 lbs. initial body weight) was initiated on February 11, 2011 and continued until May 3, 2011. Hay was harvested on May 10 after stockers were removed and summer grazing of heifers and steers (n = 64; 589 ± 9.5 lbs. initial body weight) commenced on June 2, 2011 and was finalized September 1, 2011.

Economic Analysis

Fertilizer prices were five-year averages (2008-2012) for selected fertilizers (urea, super-phosphate, and potassium chloride) presented in $/elemental lb. shown in Table 2 (USDA-ERS, 2012). Custom fertilizer application cost was estimated to be $6.00 per acre per application. Crimson clover, white clover, and ryegrass seed prices were obtained from local farm input supply companies in the fall of 2012. Hay prices were the five-year annual average (2008-2012) prices reported by USDA for other hay. Cattle prices were the five-year average monthly sale price in 50-pound increments for steer or heifer calves for Oklahoma City (LMIC, 2013). All other costs, fence maintenance, land, labor, equipment, cattle transport, and veterinary services, were assumed to be incurred regardless of pasture treatment and thus were not included in this partial returns analysis. Cattle revenue, hay harvested, fertilizer cost, and seed cost were used to calculate partial returns for 24 pastures (4 treatments x 2 pasture replicates x 3 years) as follows:

(1) $$PR_{ijk} = CR_{ijk} + HR_{ijk} - FC_{ij} - SC_i$$

where,

- PR_{ijk} is the partial returns in \$ per acre for treatment *i* in year *j* for pasture *k*
- CR_{ijk} is cattle revenue in \$ per acre for treatment *i* in year *j* for pasture *k* (shown below)
- HR_{ijk} is hay revenue in \$ per acre for treatment *i* in year *j* for pasture *k* (harvested hay in lbs. divided by 1,200 lbs./bale multiplied by hay price in \$ per bale divided by number of acres in pasture *k*)
- FC_{ij} is fertilizer cost in \$ per acre for treatment *i* and year *j* (elemental N, P, and K quantities in lbs./acre multiplied by elemental price in \$ per lb. plus application costs multiplied by number of applications in year *j*)
- SC_i is seed cost for treatment *i* (each species in

treatment *i* is estimated and then summed as: seeding rate in pounds per acre multiplied by seed cost in $ per pound. The costs of the seeder, fuel, labor, and tractor are ignored as they are incurred regardless of treatment).

$$(2) \quad CR_{ijk} = \sum_{n=1}^{5} (EW_{ijkn} \cdot P_e - SW_{ijkn} \cdot P_s) + \sum_{n=1}^{8} (EW_{ijkn} \cdot P_e - SW_{ijkn} \cdot P_s) \Big/ A_k$$

where,

- EW_{ijkn} is the ending weight for animal *n* in pasture *k* in year *j* for treatment *i* (n =5 for spring grazing; n= 8 for summer grazing)
- P_e is the monthly price ($/cwt) for animal n based on gender, ending grazing date (*e*), and ending weight (*EW*)
- SW_{ijkn} is the starting weight for animal *n* in pasture *k* in year *j* for treatment *i* (n =5 for spring grazing; n= 8 for summer grazing)
- P_s is the price ($/cwt) for animal *n* based on gender, starting grazing date (*s*), and starting weight (*SW*)
- A_k is the number of acres in pasture *k*

Using the partial returns calculated above, and shown in Table 3, a breakeven price for N fertilizer was estimated. This breakeven price for N is the N price at which producers would enhance returns by switching from the treatment with the highest partial returns prior to the N price change to the next profitable treatment when N price is changed and was estimated as:

$$(3) \quad N_p = \frac{[TR_{Max} - TR_{Next} + SC_{Next} - SC_{Max} + AC_{Next} - AC_{Max} + P_p \cdot (PQ_{Next} - PQ_{Max}) + K_p \cdot (KQ_{Next} - KQ_{Max})}{NQ_{Max} - NQ_{Next}}$$

where,

- N_p is the breakeven price of elemental nitrogen in $/lb
- *TR* is total hay and calf revenue for a particular treatment in $/acre
- *SC* is the seed cost of a particular treatment in $/acre
- *AC* is the fertilizer application costs of a particular treatment in $/acre
- *PQ* is the quantity of elemental phosphorous applied for a particular treatment in lbs/acre
- *KQ* is the quantity of elemental potassium applied for a particular treatment in lbs/acre
- *NQ* is the quantity of elemental nitrogen applied for a particular treatment in lbs/acre
- P_p is the price of elemental phosphorous in $/lb
- K_p is the price of elemental potassium in $/lb
- *Max* is the treatment with the highest partial returns prior to the change in the price of N
- *Next* is the treatment with the second highest partial returns prior to the change in the price of N

Note that if the profit maximizing treatment is the least N using treatment or the second best alternative uses the same amount of N fertilizer, then there is no breakeven price. In essence, the second best treatment prior to the N price change needs to use less N fertilizer than the profit-maximizing treatment prior to the N price change.

Experimental Design and Statistical Analysis

Each of the eight pastures were randomly assigned to one of four treatment combinations, two per treatment combination. The treatments formed a 2 × 2 factorial structure with the presence or absence of crimson clover or white clover as the factors. Data were taken from each pasture for three consecutive years for both spring and summer grazing periods. The economic data were analyzed as a split-plot where the whole-plot portion was the 2 × 2 clover factorial and year was the split-plot factor. For the animal performance analysis as measured by average daily gain (the weight gain over the grazing period divided by the number of days grazed), the grazing season formed a split-split plot factor. Statistical analysis was performed using Proc MIXED in SAS® Version 9.3 (SAS Institute Inc, Cary, NC).

Results

Hay, Cattle, and Partial Returns

Results from this analysis provide an estimation of different fertilizer/legume strategies for bermudagrass pastures overseeded with ryegrass. While results are specific to the pasture conditions described above they can be used to guide managers considering whether legumes should be used to replace commercial N fertilizer in their pasture system. Table 4 shows the analysis of variance results for performance comparisons among the different pasture treatments in terms of per acre results on hay revenue, cattle revenue, and partial returns that take revenue and cost differences among treatments into consideration. A comparison of annual means of hay revenue as portrayed in Table 5 is based on the statistically significant Crimson × Year effect. Adding crimson clover to pastures reduced hay revenue by approximately $48 and $71 in 2009 and 2010, respectively. In 2011, however, pastures with crimson clover yielded similar revenue as the pastures without clover. Recall that spring fertilizer was not applied in 2011. Given these results it may be that the other forages curtailed crimson clover production in 2009 and 2010 as their growth was enhanced with fertilizer more so than the crimson clover. From the perspective of hay revenue, the use of crimson clover is thus not advised.

Annual cattle revenue numbers showed a statistically significant Crimson × White × Year effect in Table 4 and hence Table 6 allowed comparison across the four pasture treatments. The *Conv* pastures had the most promising revenue results while the *W* pasture had the closest similar performance in 2010 and 2011. Both the *C* and *CW* pasture performed less satisfactorily. Quite noticeable is the effect of the delayed onset of grazing in 2009 with the clover overseeded pastures in comparison with the *Conv* pasture without clovers. This was potentially a result of insufficient N-availability for the onset of ryegrass production in the clover overseeded pastures in 2009. All pastures overseeded with clover had lesser revenue in 2009 than 2010 or 2011. Generally lower cattle revenue in 2010 is likely the result of wildlife grazing described above. In 2010, the *C* pastures also had statistically significantly lower revenue than the *Conv* pasture. Note that these results are impacted by both length of grazing season and animal performance.

Partial returns were calculated as hay and cattle revenue less fertilizer and seed cost (including application costs) for ryegrass, white, and crimson clover and statistically significant Crimson Clover, White Clover, and Year effects were observed (Table 4). Table 7 suggests that the addition of crimson clover to pastures statistically significantly lowers partial returns by $117 compared to partial returns observed for *Conv* and *W* pastures and that the addition of white clover lowers partial returns by $96 compared to *Conv* and *C* pastures. Either way, the addition of clovers does not appear cost effective but the addition of white clover is much closer to the LSD of $94.84. The year-by-year analysis across all pasture types mirrors the results discussion so far and reflects the lower returns due to delayed grazing in 2009, wildlife damage in 2010 and the effect of fertilizer savings in 2011 (no spring fertilizer application).

Animal Performance

The analysis of variance results for average daily gain reported in Table 8 suggested no statistically significant effects associated with the forage species mix in the pastures. This appears in contrast to the annual cattle revenue results discussed in Table 6 which involved both animal performance and number of grazing days. Average daily gain data remove the effect of length of grazing season as observed in 2009 and added greater variance as more individual animal data could be used for each pasture. Grazing season effects are likely a function of heat stress and forage quality. Year-to-year variation in average daily gain as shown in Table 9 was likely also affected by gender of cattle and weather fluctuations but equally so by pasture treatment and thereby of no relevance for the purposes of this study. These results suggest that forage species mix does not affect animal performance and further that inclusion of clovers has a negligible impact on average daily gain at least under the conditions in this study.

Fertilizer Price Breakeven Analysis

Given the dominance in partial returns of the *Conv* pasture treatment, the second best alternative, *W*, allowed the calculation of the price for N fertilizer that would lead a producer to switch from using commercial fertilizer only to overseeding pastures with nitrogen-fixing clover as a commercial fertilizer substitute. Using average PR, revenue, and cost data across all three experiment years, the N fertilizer price needed to switch from commercial fertilizer only was estimated at $1.75 per pound. Using the mid-year of the experiment or 2010 only, the N fertilizer price point was slightly lower at $1.39 per pound but still 2.5 times the level of the current price of $0.56 per pound for N. At N fertilizer prices below $1.75 per pound or $1.39 per pound, partial returns would be lower for clover treatments than those realized from commercial N.

Conclusions and Discussion

This paper analyzed hay, cattle, fertilizer, and seed cost differences associated with the potential use of clovers as a substitute for commercial N fertilizer on bermudagrass pastures overseeded with ryegrass for grazing stocker cattle in spring and summer. The results suggest that animal performance, as revealed in average daily gain, were not affected with the inclusion of clovers in overseeded pastures. The use of crimson clover compared to white clover resulted in lower returns as a function of both hay and cattle revenue. While the first year of the experiment was affected by the delayed onset of grazing in the clover treatments, the overall result of the study suggest that overseeding of clovers is not cost effective at current N fertilizer prices and, further, that N fertilizer prices would need to increase substantially before the use of clovers would be recommended on the basis of these study results. These findings are similar to Biermacher et al. (2012).

This paper highlights the difficulty of including N-fixing legumes into beef cattle production systems. Legumes are highly site-specific in terms of soil and climatic conditions such as pH and total as well as seasonal distribution of rainfall. In addition, competition from grasses in the southeastern U.S. are largely due to plant vigor and favorable growing conditions. Many of the legumes currently available were developed for areas farther north and may not work well in multi-species pasture environments. Further research may analyze potential ramifications of seeding rates on the performance of such clover based grazing strategies. Different timing and rates of fertilizer application may also lead to different results. In addition, research may focus on intensifying grazing systems by cultivating legumes and grasses in separate paddocks and using stocking methods appropriate for forage according to their different growth patterns.

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Table 1. Timing, Type, and Quantity (lbs./acre or tons/acre for lime) of Fertilizer Applied to Pastures in a 2009-2011 Legume Study at the University of Arkansas Southeast Research and Extension Center in Monticello, Arkansas

Month, Year of Application	Fertilizer Type (N-P-K)	Lbs/acre or Tons/acre (Lime)			
		Conv	W	C	CW
November, 2008	19-19-19	300	-	-	-
November, 2008	0-23-30	-	200	200	200
February, 2009	34-0-0	150	60	60	60
June, 2009	34-0-0	150	-	-	-
November, 2009	19-19-19	300	-	-	-
November, 2009	6-24-24	-	300	300	300
November, 2009	Lime	1.5	1.5	1.5	1.5
March, 2010	34-0-0	180	100	100	100
November, 2010	19-19-19	300	-	-	-
November, 2010	6-24-24	-	300	300	300

Table 2. Input and Hay Prices Used in a 2009-2011 Legume Study at the University of Arkansas Southeast Research and Extension Center in Monticello, Arkansas

Variable	Unit	Price [1]
Nitrogen	$/lb	0.56
Phosphorous	$/lb	0.72
Potassium	$/lb	0.53
Fertilizer Application	$/acre	6.00
Crimson Clover Seed	$/lb	2.03
White Clover Seed	$/lb	5.04
Ryegrass Seed	$/lb	1.40
Hay Price (1,200 lb Bale)	$/bale	69.28

[1] Prices for nitrogen, phosphorous, and potassium are five year average (2008-2012) prices in $/elemental lb from USDA ERS Fertilizer Use and Price: Average U.S. Farm Prices for Selected Fertilizers for urea, super-phosphate, and potassium chloride http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx; Fertilizer application costs were taken from University of Arkansas Crop Cost of Production Estimates. Prices for crimson and white clover and ryegrass seed were obtained from local farm input suppliers; Hay price is the 5-year average price (2008-2012) for other hay reported by the USDA ERS http://search.ers.usda.gov/search?affiliate=ers&query=hay%20prices

Table 3. Annual and Average Hay Revenue, Cattle Revenue, Seed Cost, Fertilizer Cost, and Partial Returns (PR) in $/acre by Year and Pasture Treatment for a Spring and Summer Grazing Study, Monticello, Arkansas, 2009-2011

Treatment[1]	YR1	YR2	YR3	Average
		Hay Revenue		
CW	73	64	108	82
C	129	92	130	117
W	131	105	93	110
Conv	167	193	148	169
		Cattle Revenue		
CW	173	232	251	219
C	183	225	273	227
W	186	294	321	267
Conv	361	313	325	333
		Seed Cost		
CW	95	95	95	95
C	63	63	63	63
W	75	75	75	75
Conv	42	42	42	42
		Fertilizer Cost		
CW	88	142	117	115
C	88	142	117	115
W	88	142	117	115
Conv	178	183	109	157
		Partial Returns (PR)[2]		
CW	63	59	147	90
C	162	112	223	166
W	154	182	223	187
Conv	308	280	321	303

Notes:

1 All treatments were overseeded with ryegrass. The *Conv* treatment used commercial fertilizer only. The *C*, *W*, and *CW* treatments used crimson and white clover or both, respectively, in conjunction with lesser commercial fertilizer application rates.

2 Partial returns in $/acre per pasture are cattle revenue + hay revenue – fertilizer cost – seed cost. Numbers may not add due to rounding

Table 4. Analysis of Variance Results on Hay and Cattle Revenue as well as Partial Returns (PR) by Year and Treatment Effect of Presence or Absence of Crimson and/or White Clover, Monticello, Arkansas, 2009 to 2011

	DF		Hay[1]		Cattle		Partial Returns	
Effect [2]	Num.	Denom.	F-value	p-value[3]	F-value	p-value	F-value	p-value
Crimson	1	4	3.44	0.14	9.67	0.04	11.73	0.03
White	1	4	4.74	0.10	2.22	0.21	7.95	0.05
Crimson × White	1	4	0.31	0.61	1.34	0.31	0.35	0.59
Year	2	8	1.07	0.39	15.67	<0.01	13.02	<0.01
Crimson × Year	2	8	9.13	0.01	1.04	0.40	2.01	0.20
White × Year	2	8	0.73	0.51	8.18	0.01	1.64	0.25
Crimson × White × Year	2	8	3.13	0.10	8.04	0.01	0.16	0.85

Notes:

1 Hay and Cattle represent annual hay and cattle revenue in $/acre. Partial returns calculated as cattle and hay revenue less fertilizer and seed cost on a $/acre basis.

2 All treatments were overseeded with ryegrass. The *Conv* treatment used commercial fertilizer only. The *C*, *W*, and *CW* treatments used crimson and white clover or both, respectively, in conjunction with lesser commercial fertilizer application rates. Production years included 2009, 2010 and 2011.

3 A p-value smaller than 0.05 indicates statistical significance at the 5% level.

Table 5. Mean Annual Hay Revenue Comparisons by Year and Crimson Effect, Monticello, Arkansas, 2009 – 2011

Effect[1]		**Year**	
	2009	2010	2011
	--- Mean Hay Revenue in $/acre[2] ---		
No Crimson	149.00	148.67	120.77
Crimson	101.33	77.69	118.82

Notes:

1 All treatments were overseeded with ryegrass. The *Conv* treatment used commercial fertilizer only. The *C*, *W*, and *CW* treatments used crimson and white clover or both, respectively, in conjunction with lesser commercial fertilizer application rates. Production years included 2009, 2010, and 2011. The Crimson effect is observed on *C* and *CW* pastures. The No Crimson effect is observed on *W* and *Conv* pastures.

2 Mean Hay Revenue was calculated using 4 observations. Least significant differences (LSD) at the 5% significance level for comparisons within the same row or effect are $LSD_{0.05} = 26.79$. For statistical comparison across effect and/or year or within columns and across columns but not the same row use $LSD_{0.05} = 63.90$.

Table 6. Mean Annual Cattle Revenue Comparisons by Year and Treatment Effect, Monticello, Arkansas, 2009 – 2011

Effect[1]	**Year**		
	2009	2010	2011
	--- Mean Cattle Revenue in $/acre[2] ---		
CW	173.34	231.66	251.48
C	183.41	225.08	272.78
W	185.87	294.30	321.46
Conv	361.36	312.74	324.55

Notes:

1 All treatments were overseeded with ryegrass. The *Conv* treatment used commercial fertilizer only. The *C*, *W*, and *CW* treatments used crimson and white clover or both, respectively, in conjunction with lesser commercial fertilizer application rates. Production years included 2009, 2010, and 2011.

2 Mean cattle revenue was calculated using 2 observations. Least significant differences (LSD) at the 5% significance level for comparisons within the same row or effect are $LSD_{0.05}$ = 52.27. For statistical comparison across effect and/or year or within columns and across columns but not the same row use $LSD_{0.05}$ = 106.98.

Table 7. Mean Annual Partial Return Comparisons by Treatment Effect and Year, Monticello, Arkansas, 2009 – 2011

Effect[1]	**Absent**	# of obs.	**Year**	Mean Partial Return in $/acre		$LSD_{0.05}$[2]
Crimson	Yes	12		244.78	a	94.84
	No	12		127.77	b	
White Clover	Yes	12		234.44	a	94.84
	No	12		138.10	b	
Year		8	2009	171.81	b	33.76
		8	2010	158.31	b	
		8	2011	228.70	a	

Notes:

1 All treatments were overseeded with ryegrass. The *Conv* treatment used commercial fertilizer only. The *C*, *W*, and *CW* treatments used crimson and white clover or both, respectively, in conjunction with lesser commercial fertilizer application rates. Production years included 2009, 2010, and 2011. The Crimson effect is observed on *C* and *CW* pastures. The White Clover is observed on *W* and *CW* pastures. The Year effect compares all pasture types by year.

2 A $LSD_{0.05}$ value is used to statistically compare mean partial return levels by effect at the 5% significance level. Letter rankings are provided next to the mean partial returns to differentiate by effect.

Table 8. Analysis of Variance Results on Mean Average Daily Gain by Pasture Treatment for Spring and Summer Grazing Periods, Monticello, Arkansas, 2009 to 2011

	DF		**Average Daily Gain**	
Effect[1]	Num.	Denom.	F-value	p-value[2]
Crimson	1	4	0.43	0.55
White	1	4	1.94	0.24
Crimson × White	1	4	0.00	0.98
Year	2	8	28.37	<0.01
Crimson × Year	2	8	0.51	0.62
White × Year	2	8	1.28	0.33
Crimson × White × Year	2	8	0.71	0.52
Season	1	12	390.28	<0.01
Crimson × Season	1	12	0.30	0.59
White × Season	1	12	0.87	0.37
Crimson × White × Season	1	12	0.00	0.95
Year × Season	2	12	6.78	0.01
Crimson × Year × Season	2	12	0.43	0.66
White × Year × Season	2	12	0.17	0.84
Crimson × White × Year × Season	2	12	0.04	0.96

Notes:

1 All treatments were overseeded with ryegrass. The *Conv* treatment used commercial fertilizer only. The *C*, *W*, and *CW* treatments used crimson and white clover or both, respectively, and in conjunction with lesser commercial fertilizer application rates. Season refers to the spring vs. summer grazing programs each year. Production years included 2009, 2010 and 2011.

2 A p-value smaller than 0.05 indicates statistical significance at the 5% level.

Table 9. Mean Average Daily Gain Comparisons by Year and Season, Monticello, Arkansas, 2009 – 2011

Season[1]		**Year**	
	2009	2010	2011
	--- Mean Average Daily Gain in lbs/hd/day[1] ---		
Spring	2.187	3.180	2.805
Summer	0.957	1.230	1.016

Notes:

1 The length of grazing season for spring and summer varied from year to year and varied across treatments for spring in 2009 with a longer grazing season for the pastures with ryegrass and commercial nitrogen fertilizer compared to the clover seeded treatments.

2 Mean average daily gain was calculated using 8 observations. Least significant differences (LSD) at the 5% significance level for comparisons within the same column or season are $LSD_{0.05}$ = 0.316. For statistical comparison across years and/or season or within rows and across rows but not the same column use $LSD_{0.05}$ = 0.296.