

# Effect of Timing of Urea Application or Red Clover Incorporation on Forage and Animal Production

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## Abstract

Efficient use of land resources is a major objective for beef cattle producers. Incorporating high nutritive value forages into warm perennial grasses, increases animal production and reduces hay feeding, hence reducing production costs. The moment of chemical fertilizer application or the use of clovers to provide N in pastoral systems can be possible strategies to reduce inputs and decrease negative effects in the environment (N losses through leaching or evaporation) without affecting animal performance and gains per unit of land. In the conditions of the present experiment, the treatment with one application of N (as urea) in January (after grazing started) produced the same amount of forage, average daily gains (ADG), and gain per hectare than the treatment with two applications (November and January) at a lower cost of production. When red clover (legume) was used with annual ryegrass without any chemical fertilizer, forage and animal performance were reduced when compared to the other two treatments and cost of production was the greatest. Strategically applying N based on plant growth patterns and grazing management strategies, reduced cost of production without any impact on the animal-plant subsystem. Legumes as a source of N for annual pastures may not be enough to maintain appropriate production while seed cost should also be considered.

**Keywords:** annual ryegrass, clovers, fertilization strategy, grazing, overseeding, urea

## 1. Introduction

If inputs are not limiting, it is possible to grow abundant forages on nearly any land in warm climates where temperatures and solar radiation provide potential for extended growing seasons (Muir, Pitman, & Foster, 2011). Because of the need to be profitable, beef cattle producers must combine all management practices (fertilization, use of herbicides, seed inputs, stocking rates, etc.) and resources available (land, labor, etc.) with maximum efficiency, reducing costs when possible. The technique of sod-seeding warm season perennial pastures has been used for more than 50 years (Blackmore, 1952; Dudley & Wise, 1953; Stephens & Marchant, 1958) to supplement dormant grass pastures with legumes, cereals and forage grasses (Swain, Decker, & Retzer, 1965; Hoveland & Carden, 1971). Coats (1957) found that crops drilled into permanent pastures offer an excellent opportunity for extending the grazing season and for producing hay or grain from pastureland that would otherwise be left idle during the winter months. Overseeding warm-season perennial grasses with cool-season annuals is a common practice in the southeastern United States to extend the grazing season and thereby reduce the winter feeding period, which is the greatest expense for maintaining beef cattle throughout the year (DeRouen, Prichard, Baker, Jr., & Stanley, Jr., 1991; Mooso, Feazel, & Morrison, 1990). Grazing these sod-seeded forages offers the potential to improve land use efficiency (Moyer, Coffey, Brazle, & Schneider, 1995) and to improve animal gains relative to gains expected from cattle grazing other dormant forages during the winter (Ellis & Lippke, 1976; Wilkinson & Stuedemann, 1983). The cool-season forages provide winter and spring grazing that reduce the need for stored forages (DeRouen, Prichard, Baker, Jr., & Stanley, Jr., 1991); have a greater nutritive value that results in better animal performance than warm-season grasses (Ellis & Lippke, 1976); provide spring weed control (Evers, 1983); and, if a legume, adds nitrogen to the pasture system (Evers, 1985). Seasonal forage production from winter annual forages varies considerably across forages and climatic conditions, and interseeding these forages into sods of warm season perennial grasses generally increases this variability (Moyer & Coffey, 2000). In the Gulf Coast region, growing season of warm-season perennial grasses is still occurring when the window for winter annuals planting starts (Scaglia & Boland, 2014a). Due to this, in

autumn during cool-season annual establishment there is competition for moisture, nutrients, and light. Competition during this time of the year is the most critical because it influences cool-season forage establishment, seedling growth, and early forage production. This in turn, affects the length of the grazing season, hence beef production per animal and unit of land, which ultimately will affect the economic return on winter pasture input costs. Because of the simplicity of operation, interseeding of small grains into warm-season grass sod is common throughout the southeastern United States (Beck, Stewart, Phillips, Watkins, & Gunter, 2007). The amount and timing of forage production varies by species and location (Kee, Duffy, & Ward, 1988; West, Walker, Stoin, Bacon, & Longer, 1988; Nelson, Ward, & Crowder, 1993). The use of herbicides to control growth on bermudagrass (*Cynodon dactylon*) thus enhancing the probability of establishment of the cool season pastures has been evaluated. Cuomo & Blouin (1997) reported a greater forage production in treatments where glyphosate or paraquat were used when evaluating the use of the methods to plant ryegrass into summer annual grasses. More than a million hectares of annual ryegrass (*Lolium multiflorum* Lam.) are seeded each year (Evers, Smith, & Hoveland, 1997) due to its ease of establishment and adaptation to light sandy to heavy clayey soils. The importance of pasture legumes for improving N status of soils and for maintaining a high level of total sward production without N fertilizer has long been recognized. With the increasing interest in low-input sustainable agriculture throughout the world and the concern about possible environmental problems associated with high N fertilizer use, interest has rekindled in using pasture legumes in Europe and USA as a source of biologically fixed N (Ledgard & Steele, 1992).

The objective of the present experiment was the evaluation of application timing of a chemical fertilizer (urea) or the use of red clover as N sources for grazed annual ryegrass and bermudagrass hay production in the following summer.

## 2. Materials and Methods

The present study was conducted in three consecutive winters at the Louisiana State University Agricultural Center (LSU AgCenter) Iberia Research Station (IRS) located in Jeanerette, LA (29° 57' 54" W latitude; 91° 42' 54" N longitude; altitude 5.5 m). The soil type is classified as Iberia silty clay loam with risk of flooding, although the experimental area had previously been shaped to improve drainage.

### 2.1 Weather Data

Monthly information on average air temperature (°C) and rainfall (mm) was obtained from a weather station located at the IRS approximately 148 m from the center of the experimental site. Monthly average weather data for the last 45 yr (1970-2015) were obtained from <https://www.ncdc.noaa.gov/cdo-web/> (select Jeanerette, LA).

### 2.2 Description of Treatments

Six 1.34 ha pastures of bermudagrass (*Cynodon dactylon*; cv. Tifton-85) were used. These pastures were used for grazing and hay production for the last 15 years. During this time every 3 years, soil samples were taken, and fertilizer applied based on soils analyses. At the time of starting the experiment, soil's nutrient analysis was as follows: pH: 6.36, %C: 2.806, %N: 0.2553, P: 62.6 mg/kg, S: 17.3 mg/kg, K:181.6 mg/kg, Ca: 4207.2 mg/kg, and Mg: 699.4 mg/kg. In the summer of the 3 years of the present study these pastures were used for hay production (no grazing). Number and weight of round bales (1.5 x 1.5 m) were determined. Three treatments were evaluated (2 replicates): 1) annual ryegrass (cv. 'Marshall') planted in September of each year and N fertilized with 2 applications of 55 units of N per ha each. The first one approximately 61 d after planting (in mid-to-late November) and the second one at an average of 115 days after planting (late January, early February); 2) Same as 1, but only one N application (55 units of N) in late January to early February; 3) Same as 1 with the addition of red clover (*Trifolium pratense*; cv. 'Red Ace') to the clover box of the no-till and planted at 13.5 kg/ha simultaneously with the annual ryegrass with no N fertilization during the entire grazing season. Every year and when weather permitted, bermudagrass was hayed for the last time in September, no herbicide was used to decrease its growth. Within a week of haying, treatments were planted as previously described with a 4.5 m no-till planter (1590 John Deere®, Moline, IL). Grazing started on average on d 112 after planting at an average forage mass of 2,000 kg DM/ha and a height of 19.4 cm (not all treatments started at the same time). The average length of grazing season was 90 d (95, 82, and 91 d, for year 1 through 3, respectively). On the first of January of each year, 1 L ha<sup>-1</sup> of 2-4D (2,4-dichlorophenoxyacetic acid 46.6%) was applied in pastures from Treatments 1 and 2 to control buttercup. No 2-4D was used in Treatment 3 due to negative effect on clovers.

### 2.3 Forage Measurements

Forage mass was determined at the beginning of the trial (d 0; grazing started at approximately 90) and every 14 d thereafter as described in Scaglia (2020). Botanical composition was estimated following the dry-weight-rank

method ('T Mannetje & Haydock, 1963) starting 30 days after planting (on average 75 days before d 0, when grazing started) and every 15 days thereafter until the end of the grazing period. Ten 1 m<sup>2</sup> quadrats in each paddock were clipped to 2.5 cm and samples separated in bermudagrass, annual ryegrass, red clover (only from 2 pastures), and weeds (broadleaves such as buttercup or grasses such as little barley). Each fraction was then dried (force air oven at 55 °C for 48 h), weighed and percent (per weight) estimated. Samples of forage for nutritive value analyses were hand-plucked from every paddock every 14 d (starting on the day 0 or beginning of grazing), dried and processed for analyses at a commercial laboratory (Dairy One Forage Laboratory, Ithaca, NY).

#### 2.4 Animal Management and Sampling

The animal handling procedures used in this experiment were approved by the LSU AgCenter Animal Care and Use Committee. Every year, 30 crossbred (*Bos Taurus* x *B. indicus*; no more than ¼ *B. indicus* influence) steers (203 ± 24 kg) were blocked by weight and randomly allotted (n=5) to pastures. They were continuously stocked at 3.7 steers ha<sup>-1</sup> or 755 kg BW/ha. Prior to weaning, steers were vaccinated according to Research Station's protocol twice (August and September of every year). After weaning (mid-October of each year) until approximately 2 weeks before the start of the grazing period, steers were fed bermudagrass hay (*ad libitum*) and a supplement with 20% CP and 72% TDN at a rate of 0.5% bodyweight. Steers were dewormed again on d -1 with an ivermectin (Ivomec, Boehringer Ingelheim). Steers were weighed on d 0 and every 15 d thereafter to determine average daily gains (ADG) per each 15-d period, total ADG for the entire grazing period, and beef produced per unit of land. The latter was estimated by the sum of the difference between final and starting BW of each animal, divided by the area (1.34 ha) of each paddock.

#### 2.5 Economic Analyses

Prices for inputs (seed, fertilizer, herbicide) were averaged across years of the experiment. Other information was taken from Boucher & Gillespie (2014). Cost of production (\$/kg) was estimated as the coefficient between the total expenses incurred per hectare and beef produced per hectare.

#### 2.6 Statistical Analyses

The experiment was a completely randomized design with two replicates. Data were analyzed with PROC Mixed of SAS (version 9.4, SAS Inc., Cary, NC). Treatment and year were considered fixed effects and paddock the experimental unit. All variables (forage mass, forage height, and nutritive value, average daily gains, and gain per unit of land) were analyzed for treatment, year and their interaction.

### 3. Results

Table 1. Weather data (monthly averages for maximum and minimum temperatures and total rainfall) for the grazing seasons 2014-2015 (Year 1), 2015-2016 (Year 2), and 2016-2017 (Year 3) obtained at the Iberia Research Station and historical data for the previous 45 years

	Year 1			Year 2			Year 3			HISTORIC <sup>1</sup>		
	Max <sup>2</sup>	Min <sup>3</sup>	Rain <sup>4</sup>	Max	Min	Rain	Max	Min	Rain	Max	Min	Rain
J <sup>5</sup>	31.2	22.2	164.2	31.4	22.4	267.3	32.0	21.8	145.3	31.2	21.2	208.8
J	31.5	21.9	280.5	33.6	23.6	44.4	31.6	22.4	113.0	32.6	22.3	171.3
A	31.9	22.6	270.2	33.2	22.1	145.2	32.4	22.9	548.4	32.1	22.5	172.1
S	30.5	21.0	73.9	30.4	20.5	130.2	30.1	20.1	274.3	30.8	19.2	162.9
O	27.8	14.6	33.0	27.6	14.9	151.7	28.1	15.4	20.6	26.5	14.9	129.1
N	18.9	6.0	41.9	22.9	13.3	346.6	19.9	11.9	44.5	22.1	10.2	100.4
D	19.2	8.2	97.0	21.0	11.2	108.6	20.4	8.1	192.3	17.9	6.1	128.5
J	14.9	3.8	84.4	15.4	4.6	162.8	15.3	5.6	148.6	16.0	5.8	124.8
F	15.6	3.5	57.7	19.3	6.8	100.3	17.4	2.9	90.4	18.2	7.0	111.8
M	22.6	11.8	100.2	23.0	13.1	164.6	23.0	11.2	70.1	21.6	10.1	99.9
A	26.4	17.1	279.3	25.8	15.9	131.9	26.7	16.7	51.6	25.1	14.4	102.2
M	29.3	19.7	214.3	28.1	18.6	260.3	28.6	19.0	342.9	29.4	18.5	110.8

<sup>1</sup>HISTORIC: Historic weather data (1970-2015)

<sup>2</sup>Max: Average maximum monthly temperatures, Celsius

<sup>3</sup>Min: Average minimum monthly temperatures, Celsius

<sup>4</sup>Rain: Monthly rainfall, mm

<sup>5</sup>Months of the year, from J (June) to M (May) of the following year

Table 1 shows the weather conditions in three consecutive years at the Iberia Research Station. The greatest

impact was caused by rainfall. In Year 1, from September to February, monthly rainfall oscillates from 25% (October) to 75% (December) of the average historic rainfall for each month. On Year 2, rainfall was similar or above the historic values for most of the months, with the month November, notably the greatest, with 3 times the average historic rainfall. In Year 2, the total rainfall since the time there is a need to start land preparation (August-September, haying and planting) until the end of the grazing season (April) was 1,442 mm, and the historic average was 1,132 mm. Year 3 was much more variable with very wet months (for example, August due to a tropical system that caused widespread flooding in south Louisiana), or very dry months (October rainfall was 20% and November 45% of the historic average for those months). Rainfall affected pasture productivity and hence impacted grazing days and animal performance through the effect on late planting (Year 3), drought during growing season (Year 1), or excess seasonal rainfall (Year 2), among others.

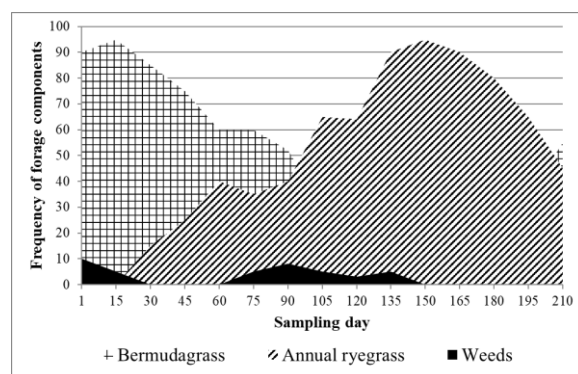
Table 2. Effect of treatment (TRT) and year (YEAR) on forage mass (kg/ha), height (cm) and nutritive value parameters (% DM) of experimental pastures

Item	Treatment <sup>1</sup>			SEM	P values		
	1	2	3		TRT	YEAR	TRTxYEAR
Forage mass, kg/ha	2268a	1840a	1321b	252	0.02	0.04	0.11
Forage height, cm	20.9a	18.9ab	16.1b	2.1	0.03	0.06	0.09
Nutritive value, % DM							
CP	18.9a	14.9b	15.1b	1.9	0.03	0.81	0.77
NDF	48.2	47.0	50.7	1.8	0.61	0.18	0.34
ADF	28.2b	31.5b	38.7a	2.9	0.01	0.04	0.49
TDN	71a	65b	68ab	2.9	0.04	0.21	0.18
IVTD	72a	70ab	67b	2.4	0.03	0.11	0.26

<sup>1</sup>Treatments: 1) Annual ryegrass and N fertilized twice with 55 units of N/ha; 2) Same as 1, but only one N application (55 units of N/ha); 3) Same as 1 but adding red clover with no N.

Forage mass and height (Table 2) were affected by treatment ( $P = 0.02$  and  $0.03$ , respectively). Annual ryegrass fertilized twice (Treatment 1) had the greatest forage mass during the grazing season and height was similar to Treatment 2 but greater than annual ryegrass and red clover pastures (Treatment 3). Treatments 2 was intermediate in forage mass production while Treatment 3 had the smallest (Table 2). There was Year effect ( $P=0.04$ ) on forage mass mainly explained due to lowest production in Year 2 (1,892, 1,479, and 2,101 kg DM/ha, for Year 1, 2, and 3, respectively). Forage nutritive value was greatest for Treatment 1. Crude protein, TDN, and IVTD were greatest and ADF concentration lowest for annual ryegrass fertilized twice.

The botanical composition of experimental pastures is depicted in Figure 1 (a, b, and c). The use of fertilizer in the Fall benefited the bermudagrass, which remained green (due to N) and more productive than when no fertilizer was available (Treatments 2 and 3). This can be observed in Figure 1a, which shows the prevalence (45% of the frequency) of bermudagrass 90 to 100 days into the sampling period. On the other hand, in Figures 1b and 1c, bermudagrass reached the same level (40-45%) of the pasture composition at approximately the same time (60 days), a significantly lower time than for Treatment 1. Annual ryegrass represented near 90% of the pasture in Treatments 1 and 2 (Figures 1a and 1b) but it was never more than 70% in Treatment 3 (Fig. 1c). Weeds were present in all three treatments although there were more in pastures from Treatment 3.



(a)

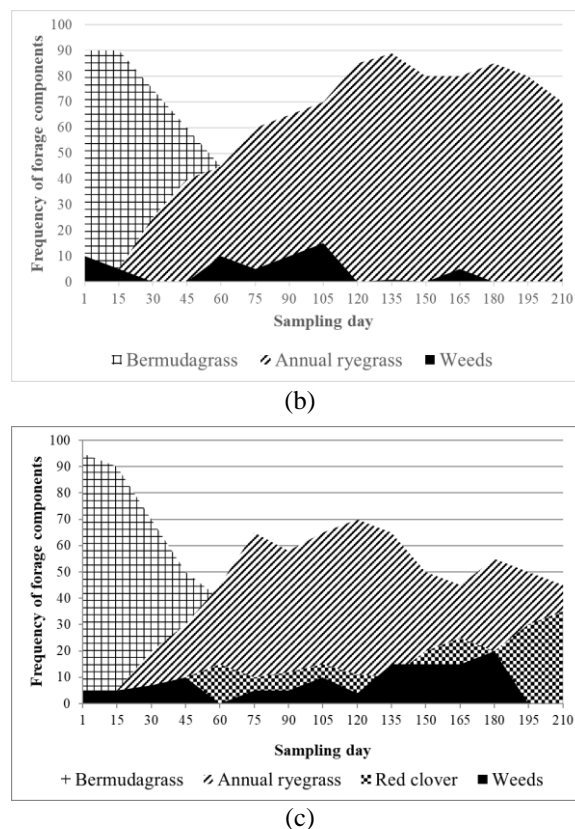


Figure 1. Botanical composition of experimental pastures: (a) Annual ryegrass and N fertilized twice; (b) Same as 1, but only one N application; (c) Same as 1 but adding red clover with no N

Grazing days, animal production (ADG and beef produced per hectare) and kg of hay produced were different ( $P=0.04, 0.02, 0.04,$  and  $0.03,$  respectively) between treatments (Table 3). Pastures in Treatment 1 reached the appropriate forage mass and height to start grazing sooner, leading to an early grazing start compared to pastures in the other two treatments; however, numerically, Treatment 2 had the greatest yields, although they were not different ( $P > 0.05$ ) to Treatment 1 but were greater ( $P < 0.05$ ) than for Treatment 3. A year effect ( $P < 0.05$ ) was observed (Table 3) for grazing days and hay production (number and weight of bales per hectare).

Table 3. Effect of treatment (TRT) and year (YEAR) on grazing days, ADG (kg), beef produced (kg/ha) and bermudagrass hay production

Item	Treatment <sup>1</sup>			SEM	TRT	P values	
	1	2	3			YEAR	TRTxYEAR
Grazing days	97a	89b	86b	3.9	0.04	0.04	0.27
ADG, kg	1.14a	1.18a	1.01b	0.05	0.02	0.31	0.64
Beef production, kg/ha	410a	392a	324b	27.2	0.04	0.08	0.29
Hay, bales/ha	1.45	1.50	1.39	0.08	0.10	0.03	0.64
Hay, kg DM/ha	585ab	612a	542b	31.2	0.03	0.04	0.81

<sup>1</sup>Treatments: 1) Annual ryegrass and N fertilized twice with 55 units of N/ha; 2) Same as 1, but only one N application (55 units of N/ha); 3) Same as 1 but adding red clover with no N.

#### 4. Discussion

Efficiency of production is always a target in any livestock production system. In pastoral systems the efficient use of land is a critical factor that affects the sustainability of the systems and hence the livelihood of the beef cattle producer. Since summer perennial grasses (bermudagrass, bahiagrass) are the staple grasses of beef production systems in the humid south, their maintenance is critical. Their production curve usually extends from late May into September, with an occasional small growth, if appropriate conditions are present (weather, fertility) in October and November (Scaglia and Boland 2014a). In the present study, N fertilization in the Fall

augmented the nutrient resources for bermudagrass which, as usual in the Gulf Coast region, may not have become dormant yet. Bermudagrass present in the Fall (Fig. 1a) is a clear response to these effects. Nutritive value of bermudagrass sampled in October (CP= 10.1%; TDN=55%) and November (CP= 8.9%; TDN=51%) proved that it absorbed a certain amount of N from the Fall fertilizer which in turn was not available for the early growth stages of annual ryegrass. As evident in Table 2, forage mass and height of the annual ryegrass was not affected by this early inefficiency in the use of N. This may also explain the fact there were no significant differences in forage mass and height between Treatment 1 and 2 (the latter had no N fertilization in the Fall). Despite the competition between annual ryegrass and bermudagrass for N during the Fall, the fact that bermudagrass growth rates are at a minimum (35 to 65 kg DM/ha) during this time (regardless of the N availability), may have positively impacted the nutritive value (CP and TDN) of annual ryegrass (Table 2). The use of legumes in pastoral systems may have different positive impacts: 1) increase pasture diversity; complex swards are systematically more beneficial than monocultures (Scaglia & Boland, 2014b); 2) improve nutritive value of pastures (Mooso, Feazel, & Morrison, 1990; Scaglia & Boland, 2014b); 3) provide N to the pastoral system (Ledgard & Steele, 1992). Productivity of annual ryegrass + red clover pastures was smaller than on the other two treatments while nutritive value parameters, in most cases, similar to Treatment 2 (Table 3). The possible explanation is that, even though legumes can fix N from the atmosphere, it does not become available within the grazing season. More than 70% of the N is present in the aerial part of the plant, which means that to become available to the rest of the pasture, the plant has to be consumed by the animal (N will be recycled to the soil through excreta) or free up after plant deterioration. Animal production (ADG and production per hectare) was the smallest for Treatment 3. Lowest ADG are explained by a lack of high quality annual ryegrass (average CP was 11% and TDN was 53% on samples taken during the 3 years from pastures on Treatment 3) which was the major forage available (Fig. 1c) during the grazing season. This fact and the smaller number of grazing days for this treatment, were the factors affecting production per hectare (Table 3).

There is limited information on warm-season perennial grass recovery in late spring following cool-season annuals after various sod-suppression practices the preceding autumn. Competition from annual ryegrass can be especially harsh since it grows through early May under grazing. A dry spring magnifies the ryegrass competition because there is little soil moisture remaining after ryegrass matures to initiate new growth of the warm-season perennial grass. This might be the effect of the low rainfall on February through April in the third year of the experiment. Number of bales per ha and weight of them was lower in Year 3 (1.1 and 459 kg DM/ha) when compared to Years 1 (1.61 bales/ha and 645 kg DM/ha) and 2 (1.59 bales/ha and 630 kg DM/ha), respectively.

The lowest cost of production for Treatment 2 is explained by the ability of the system to produce similar ADG and beef per hectare than the treatment with 2 applications; this cut the cost of fertilizer in half (Table 4). The most expensive was Treatment 3. Greater costs of seed (due to red clover) plus the lack of animal response to forage available due to lower nutritive value and shorter grazing days, explained the greater cost of the production (Table 4).

Table 4. Economic analyses (dollars per hectare) and estimated cost of production (dollars per kg of beef produced) for each treatment

	Treatment 1	Treatment 2	Treatment 3
<b>DIRECT EXPENSES, \$/ha</b>			
-Fertilizer (urea)	50.6	25.3	0.0
-Herbicide (2-4D)	8.9	8.9	0.0
-Seed (annual ryegrass; red clover)	79.2	79.2	129.8
-Diesel fuel <sup>1</sup>	6.8	5.8	5.1
-Repair & Maint. <sup>2</sup>	39.3	33.3	22.8
-Interest on capital	11.9	10.1	8.3
<b>TOTAL DIRECT, \$/ha</b>	196.7	162.6	166
<b>FIXED EXPENSES, \$/ha<sup>3</sup></b>	82.6	82.6	65.9
<b>TOTAL EXPENSES, \$/ha</b>	279.3	245.2	231.9
<b>COST OF PRODUCTION, \$/kg</b>	0.68	0.63	0.72

<sup>1</sup> Fuel used for planting, spraying herbicide, fertilizer application (Boucher & Gillespie, 2014).

<sup>2</sup> Repair and maintenance for equipment used in each of the treatments (Boucher & Gillespie, 2014).

<sup>3</sup> Fixed expenses: cost of bermudagrass planting and maintenance, fixed cost of machinery (Boucher & Gillespie, 2014).

In conclusion, a single application of urea after starting the grazing period produced similar amount of animal gain and it is more profitable than two applications of chemical fertilizer on annual ryegrass pastures planted on bermudagrass sod. This clearly indicate that the first N application may have been poorly utilized by the annual ryegrass. The use of a legume as a N source in pastures does not replace the need for N of the annual ryegrass nor impacted bermudagrass hay production.

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