Stockpiled Tifton 85 Bermudagrass Followed by Grazed Winter Cover Crops as Part of a Stocker Production System for South Alabama

by

Katherine Renee Bivens

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
August 6, 2016

Keywords: forage, stocker cattle, backgrounding, Tifton 85, cover crops

Approved by

Kimberly Mullenix, Chair, Assistant Professor of Animal Sciences
Russell Muntifering, Professor of Animal Sciences
Jennifer Tucker, Adjunct Assistant Professor of Animal Sciences

Abstract

A 2-yr grazing study was conducted in the fall of 2014 (Yr 1) and 2015 (Yr 2) to evaluate the use of stockpiled Tifton 85 (T85) for backgrounding stocker cattle compared with feeding hay plus supplement during the fall forage deficit gap. The study consisted of six 0.75-ha paddocks of stockpiled T85 and six 0.20-ha drylot paddocks for feeding T85 hay. Treatments included: Stockpiled T85 or T85 hay only (no supplement), stockpiled T85 or T85 hay plus 0.2 kg cottonseed meal and 0.7 kg soybean hulls/head/day (65 g RUP/kg supplement CP) (25/75), and stockpiled T85 or T85 hay plus 0.45 kg cottonseed meal and 0.45 kg soybean hulls/head/day (142 g RUP/kg supplement CP) (50/50). In Yr 1, steers (initial BW 280 ± 38 kg) were randomly assigned to treatments on November 11 and removed on January 6, and in Yr 2 steers (initial BW 247 ± 21 kg) were randomly assigned to treatments on October 28 and removed on December 21. Polytape fencing was used in for frontal grazing stockpiled T85 paddocks to allocate a 3- to 4-d allotment of forage DM for the animals based on 1) the available forage mass and 2) steer DMI requirements. In both Yr 1 and Yr 2, there were no differences ($P > 0.10$) among treatments in mean forage mass (5,099 kg DM/ha and 7,998 kg DM/ha in Yr 1 and Yr 2, respectively), forage allowance (1.9 kg DM/kg steer BW and 3.0 kg DM/kg steer BW) and percent forage utilization (84% and 88% in Yr 1 and Yr 2, respectively). No differences ($P > 0.10$) were detected for nutritive value parameters CP, ADF, NDF, and TDN among treatments in stockpiled T85 or T85 hay in both years. However, there were differences ($P < 0.0001$) across sampling dates for stockpiled T85 treatments only. Pre-graze forage quality in Yr 1 and Yr 2 generally declined as the grazing season progressed. In Yr 1, steer mean initial BW, mean final BW, and ADG did not differ across all treatments ($P = 0.3785$). However, differences were

detected for these parameters in Yr 2. In Yr 2, mean ADG was greater for stockpiled T85 treatments with supplementation than hay + 50/50, but intermediate to the hay + 25/75 treatment. Mean ADG of the treatments with no supplementation were less than those receiving supplementation. In Yr 1, all but one treatment (Hay + 50/50) experienced a negative mean ADG. Stockpiled T85 supplemented with CP and energy can support stocker cattle at a level of maintenance, but to achieve a desired gain of 0.9 kg/day, there must be a greater level of supplementation implemented into the program.

A 2-yr grazing study was conducted in the winter through spring 2015 (Yr 1) and 2016 (Yr 2) to evaluate combinations of cool-season annuals for supporting a winter/ spring grazing system for stocker producers as cover crops to use prior to fields being utilized for row crops. Twelve 1.21-ha paddocks with 4 replications and 3 treatments in Yr 1 and 3 replications of 3 treatments in Yr 2 were grazed. Treatments included combinations of: Florida 401 rye and Earlyploid annual ryegrass (R-E), Florida 401 rye and Marshall annual ryegrass (R-M), and Florida 401 rye and RAM Oats (R-O). Treatments were arranged in a completely randomized design. Steers (initial BW 279 ± 49 kg) were randomly assigned to treatments on February 5 and removed on April 3 in Yr 1. In Yr 2, steers (initial BW 281 ± 17 kg) were randomly assigned to treatments on in early Ferbuary, and removed during mid-March according to forage availability.. Mean forage mass and forage allowance across both Yr 1 and Yr 2 did not differ among treatments ($P > 0.10$). For Yr 1, there were no significant differences in CP, ADF, NDF, and TDN ($P > 0.10$); however, in Yr 2, there were significant differences among treatments in CP ($P = 0.0114$), ADF ($P < 0.0001$), NDF ($P < 0.0001$), and TDN ($P < 0.0001$). In Yr 2, R-O and R-E had greater nutritive quality than R-M. As expected, in both years the forage quality of all treatments generally declined as the grazing season progressed. Mean initial BW and final

BW in both years did not differ across treatments (*P* > 0.10). Additionally, there were no significant differences in mean ADG across treatments in Yr 1 and Yr 2 (*P* = 0.2130 and *P* = 0.4534, respectively). Cool-season annual forages such as small grains and ryegrass may be planted in mixtures and utilized for winter grazing systems in cover crop systems. Using mixtures of ryegrass and small grains that differ in their individual growth pattern proved to have a more even distribution and maintained high nutritive value throughout the grazing season.

Acknowledgments

First and foremost, I would like to thank God for giving me the ability and drive to pursue the opportunity that he made possible for me to achieve my goal of obtaining this degree. I would also like to thank Dr. Kim Mullenix for creating the opportunity for me to obtain this degree here at Auburn along with helping me understand and realize my potential and dream. She has provided me with experiences, values, and most importantly life-lessons that I will hope to use in not only my professional career, but also throughout my own life. Next, I would also like to thank Dr. Russell Muntifering, he has been a great mentor and has given me extremely useful knowledge that I shall hope to use in my career. Next, I would also like to thank Dr. Jennifer Tucker for her continued enthusiastic interest in my project and for providing me with helpful career and life advice. I would also like to thank Wiregrass Research and Extension Center for their daily management that made this research project possible. I would like to thank the Department of Animal Sciences for their continued encouragement throughout my graduate career. My deepest thanks go out to Susan Sladden, who oversaw my lab work as well as helped me out in collecting field samples. Not only has she been a great professional mentor, but also I would not have been able to mentally or emotionally complete this degree without her encouragement and support. I am also very thankful for a fellow graduate student, Robert McKee, he was by my side in the field, lab, and conferences and encouraged me through it all. I am also very thankful for the student workers that worked in the agronomy lab, Trey Colley, Joseph Olvey, and Zack Smith; they helped me tremendously in the field and lab. Finally, I would like to thank my family for their continued moral support during my graduate career.

Table of Contents

List of Tables

I. LITERATURE REVIEW

STOCKER CATTLE INDUSTRY

Background/Definitions

The U.S. beef industry has many different sectors. There are three different pre-harvest sectors in the U.S. cattle industry including cow-calf, stocker and feedlot operators. These stages of production occur sequentially, although sometimes the stocker phase may be skipped. The term “stocker cattle” originally referred to spring-purchased calves being stocked on lush mountain pastures (Marchant, 2014). Stocker cattle are generally young, lightweight calves (204- to 227-kg heifers and steers) that are mainly grown on grazed pasture until the desired weight (340 to 386 kg) is achieved before sending animals to the feedlot for finishing (Parish et al., 2004). In the Midwest and Western US, stocker cattle are purchased in the spring and are turned out on pasture through the summer months, then are sold in the fall with a sale weight of ~340 to 385 kg at the age ~21to 26 months of age (Schuster et al., 2001). This system differs from the traditional one in the Southeast where stocker calves are bought in the fall of the year, and allowed to graze cool-season pastures until the time of sale in the spring months.

The stocker cattle sector provides many benefits to the cattle industry as a whole. When stocker cattle reach the feedlot, they have already adapted to eating from a bunk and drinking water from a trough. Additionally, they have been vaccinated and typically have a more responsive immune system as a result of having been mixed previously with cattle from various farms and sources. Stocker calves have also experienced some type of transportation before being shipped to the feedlot for finishing (Beck et al., 2013), which means the chance of sickness or disease is decreased, a tremendous benefit when considering the close confinement of a finishing feedlot.

One of the main goals of a stocker operator is to achieve uniformity among cattle. Based on this, stocker producers will narrow their requirements for selecting cattle for their operation. When purchasing these calves, many factors such as breed type, frame score, age, muscle thickness, weight, and health of the animal come into consideration (Troxel and Barham, 2012). The producer aims to raise a uniform set of calves such that the end product will be easier to market and sell as a group. Troxel and Barham (2012) reported that 75% of the calves marketed in Arkansas were individuals, but when the cattle were marketed in groups the sale price increased by 4%. Stocker producers aim to achieve a good average daily gain (ADG) to quickly and efficiently add weight to cattle. Beck et al. (2013) stated that most profitable producers in the stocker industry produce cattle that achieve a minimum of 0.9 kg ADG.

Cattle prices are at an all time high; medium and large number 2 feeder steers have been sold for approximately $146.37/cwt with the steers averaging ~240 kg (Alabama Livestock Market News, 2016). Prices for calves are seasonal, and typically increase in winter and peak in March and April when Southeastern stocker calves are typically sold. The stocker sector can potentially be profitable at all times of the year, depending on input costs in relation to calf prices. Over the last several years, the stocker industry has increased in profitability and practice. Beck et al. (2013) reported that the value for stocker calves bodyweight gain has increased from 2000 to 2011 by 134%.

The viability of the stocker cattle industry should continue along with increased beef demand in the US. The stocker industry has increased due partly to the demand for the beef, even though cattle numbers themselves have reached an all-time-low. The price of grain has also increased over the last two decades, and so the need to decrease cost of feeding grain is needed. Ultimately, using grain and its by-products as a strategic supplement along with forage as the primary source of feed for the animal has contributed to the increase in the stocker industry. To achieve profitability, the objective is to decrease costs while increasing outputs. Using forage as the primary feed source should help decrease feed costs.

Southeast Stocker Industry

Stocker cattle management differs among geographic regions of the US. The Southeast has a temperate climate, abundant forages, and an extensive marketing infrastructure (Anderson et al., 2003), that makes it a desirable location for stocker cattle production. This region is largely focused on cow-calf production systems, which means calves are sold at or shortly after weaning (Anderson et al., 2003). The ability to grow grass nearly year-round and an ample supply of calves make the Southeast an excellent location for stocker producers. Hoveland (1986) stated that the greatest opportunity for improving profitability in beef production in the Southeast is in stocker production for these reasons.

Stocker producers aim to achieve a target gain in the most economical way possible. Managing input costs such as fertility, seed, feed, and forage is an important balance when trying to achieve a reasonable cost of gain. When purchasing calves for a fall stocker system, the forage availability has to be taken into account if the goal is to maximize utilization. In the Southeast, there is often a fall forage gap, or a period of limiting forage availability. This occurs when summer perennial grasses are decreasing in quantity and nutritive value, whereas cool-season forages are typically not ready to be grazed until late December to early January. During the fall, forage can still be used if managed properly. During this time period, producers may use stored forages such as hay, baleage, silage, stockpiled forage or a combination of these options to provide the basis of the nutrition program for stocker cattle. The forage species that have the most success under stockpiling within this region are bermudagrass (*Cynodon dactylon* L.) and tall fescue (*Festuca arundinacea* L.) due to their ability to produce adequate biomass and maintain quality (Ball et al., 2015). After the use of stockpiled forage, cool-season annuals and perennials are often utilized for grazing when they become available. Prevatt et al. (2014) reported that the forage system that will result in the lowest cost of BW gain for stocker calves is based on high-quality, cool-season grasses. Some cool-season grasses that are typically utilized for stocker operations are annual ryegrass (*Lolium multiflorum*), tall fescue (*Festuca arundinacea*), and small grains (Ball et al., 2015).

Reasons for Fall-Purchased Calves

In the Southeast, weaned calves are purchased in the fall, partly because of the calving season distribution within the region. Weaning of these calves during the late summer/early fall creates a surplus of feeder calves coming to the market in the fall of the year.

There are a few different ways stocker cattle are obtained by the producer. The producer can buy directly from the cow/calf producer, or go through an order buyer/broker (i.e., producer tells the order buyer exactly what is desired, and the order buyer/broker will gather the desired herd for producer), or the stocker producer can attend sales or auctions like at a stockyard.

Purchase of the weaned calves typically occurs in the fall in the southeastern US due to the cow-calf sector weaning calves in the fall. Calves are purchased at lighter weights, ~200 to 225 kg, and are grazed to a target weight. Stocker calves will often gain around 160 kg for a sale weight of ~360 to 410 kg. These calves graze for 120 to 150 days, depending on forage availability. Because this weight gain occurs over a short period of time, these calves average 18 to 21 months of age going into the feedlot (National Cattlemen's Beef Association, The Beef Checkoff, 2006). This is a potential benefit, because age of animal correlates with the tenderness of the meat. The younger the animal is when reaching that finished weight, influences its quality along with many other factors, as well as the elimination of the worry of Bovine Spongiform Encephalopathy (BSE) if less than 30 months of age (American Meat Institute, 2008).

WARM-SEASON FORAGE SYSTEMS

Overview

Types of warm-season forages

Warm-season forages are species that are planted in the spring to early summer and make most of their growth during the warmest months of the year (Ball et al., 2015). Forage is defined as the edible parts of plants, other than separated grain, that can provide feed for grazing animals or that can be harvested for use as feed for animals (Allen et al., 2011). Forage crops are typically characterized as an annual or perennial. Annual forages germinate, grow, reproduce and die in one growing season. Perennial forages have the ability to live for more than one year under favorable management conditions. Perennials become dormant at certain times of the year, but can recover from tubers, rhizomes or stolons in succeeding years. They can reproduce by seed or vegetatively (Ball et al., 2015).

Alabama has diverse climatic conditions, including variation in temperature and rainfall, across the state (Ball et al., 2015). Soil type also varies within the state, which influences forage species adaptation. These factors influence what forage species are adapted to different production environments within the state.

Some warm-season forages that are adapted to the lower Southeast include: bahiagrass (*Paspalum notatum L.*), bermudagrass (*Cynodon dactylon L.*), crabgrass (*Digitaria sanguinalis L.*), dallisgrass (*Paspalum dilatatum L.*), johnsongrass (*Sorghum halepense L.*), sorghum (*Sorghum bicolor L.*), pearl millet (*Pennisetum glaucum L.*), and switchgrass (*Panicum virgatum L.*) (Ball et al., 2015). These species have diverse characteristics that enable them to fit into a variety of forage management scenarios. Bahiagrass, bermudagrass, sorghum, pearl millet, and switchgrass are all relatively drought-tolerant species that can be used for pasture and hay production. Although often considered a weed, crabgrass is a desirable species that can be used for pasture or hay. Dalligrass is more widely utilized for pasture than hay production, and represents a viable perennial warm-season forage option within the region. Johnsongrass is utilized well for hay but needs extensive management to be utilized for pasture (Ball et al., 2015). Within each given species, there are different varieties that have been genetically selected for desirable forage characteristics such as adaptation, herbage production, drought tolerance, persistence and nutritive value.

Bermudagrass

Bermudagrass is a perennial, warm-season forage that can be established by rhizomes, stolons or seeds. It spreads by stolons and rhizomes. It is drought tolerant and well adapted to sandy, well-drained soils (Ball et al., 2015). The sustainability of bermudagrass is environment-specific and may be attributed to the root-rhizome-stoloniferous traits that have high tolerance to severe defoliation. Bermudagrass is often associated with high forage production and good animal performance per unit of land area (Rouquette, 2005). Most bermudagrasses are tolerant of different soil conditions, moderate to heavy grazing pressure, variable rainfall distribution and differing defoliation management. Most varieties are used in dual-purpose systems for grazing and hay production (Hill et al., 2001). Bermudagrass initiates growth 30 to 45 days after the last frost in the spring, so the grazing period for actively growing bermudagrass can range from May through October (Rouquette, 2005).

There are many different varieties of bermudagrass commercially available that have been selected for improved forage production, nutritive value, and adaptation potential in the

Southeast. There are both seeded and hybrid cultivars available on the market today. “Seeded” means that the cultivar can reproduce through its own seed that is produced. A “hybrid” is sterile and cannot reproduce from its own seed (Sleper and Poehlman, 2006). A hybrid is asexually propagated meaning that it spreads using its sprigs, stolons and rhizomes. Bermudagrass hybrids have different characteristics that impact their nutritive value, productivity, and influence on animal performance (Scaglia and Boland, 2014). Some of the most commonly used commercially available hybrids found in the Southeast include Alicia, Callie, Coastcross-1, Coastal, Jiggs, Russell, Tifton 44, Tifton 68, Tifton 78 and Tifton 85 bermudagrass.

Tifton 85

Tifton 85 bermudagrass is a commercial hybrid resulting from a cross of Tifton 68 and Stargrass (*Cynodon nlemfuensis*). Tifton 68 is a bermudagrass hybrid that is highly digestible but cold susceptible (Burton et al., 1993). Stargrass is a plant introduction from South Africa. Tifton 85 was developed by the USDA-ARS in cooperation with the University of Georgia Coastal Plain Experiment Station, Tifton, GA and released in April 1992. It is taller, has larger stems, broader leaves and a darker green color than most other bermudagrass hybrids. Tifton 85 has large rhizomes and large, rapidly spreading stolons. It can be established by planting sprigs with mechanical planters or broadcasting and disking green stems cut at an advanced growth stage into moist soil (Burton et al., 1993).

Hill et al. (1993) reported that Tifton 85 had greater forage dry matter (DM) accumulation and nutritive value than to other cultivars such as Tifton 68, Tifton 78 and Coastal bermudagrass in a clipping evaluation in Tifton, GA. Hill et al. (1993) used ruminally cannulated steers fed a diet of bermudagrass hay to determine *in vitro* dry matter digestibility (IVDMD) of Tifton 85 and Tifton 78. The Tifton 85 had greater IVDMD in May and

September, but Tifton 78 had a greater IVDMD in July, illustrating the early-growth potential and nutritive value of Tifton 85 bermudagrass. Mandebvu et al. (1999) conducted an experiment to compare herbage production, NDF and ADF concentration, and digestibility of Tifton 85 and Coastal bermudagrass using growing beef steers. The authors found that Tifton 85 had significantly greater NDF, ADF, cellulose and hemicellulose concentration than Coastal, but lower lignin concentration. The authors also reported that Tifton 85 was more digestible than Coastal bermudagrass. The fact that Tifton 85 had greater concentrations of fiber but was still more digestible appears to be contradictive. Mandebvu et al. (1999) reported the cell wall composition of Tifton 85 had lesser concentrations of ether-linked ferulic acid than Coastal bermudagrass, which suggested the chemical nature of Tifton 85 cell wall structure had been altered in its development. Scaglia and Boland (2014) also found Tifton 85 to have a higher NDF percentage and a lower lignin percentage than Alicia and Jiggs in a grazing evaluation when samples were cut to determine nutritive value. While previously thought that the most commonly recognized limitation to cell wall digestion is lignin (Van Soest, 1965), Jung and Allen (1995) found that ferulic acid linkages between lignin and cell wall polysaccharides may be a prerequisite for lignin to exert its effect. Ruminal bacteria and fungi have phenolic acid esterases that can break down ferulate ester linkages but not ether linkages (Jung and Allen, 1995). Coastal bermudagrass having a higher concentration of ether-linked ferulic acid partially explains is lower percentages of digestibility compared with Tifton 85 (Mandebvu et al., 1999).

Scaglia and Boland (2014) conducted a study to compare the effect of bermudagrass hybrid on animal performance. They reported that ADG was greater when steers grazed Tifton 85 and Jiggs than Alicia in a 112 day evaluation. Hill et al. (1993) also conducted a study to determine steer performance and forage quality from grazed Tifton 85 and Tifton 78 pastures.

There was no significant difference between the two hybrids in relation to ADG; however, Tifton 85 supported 38% more grazing days and produce 46% more gain per hectare (Hill et at., 1993).

Stockpiling

Stockpiling, sometimes referred to as deferred grazing or standing hay, can occur at any time during the year as part of a forage management plan, but usually occurs towards the end of the growing season prior to dormancy (Allen et al., 2011). To stockpile forage successfully, it must first be clipped, then fertilized and allowed to accumulate until a time of later use, typically characterized as a period of forage deficit (Ball et al., 2015). Stockpiled forages can be cut for hay or can be grazed by cattle most efficiently by using a controlled grazing method. The general idea of stockpiling bermudagrass is to utilize this accumulated forage during the early- to mid-winter months when warm-season forage has been depleted, and before the cool-season forage is ready to be grazed. Grazing stockpiled forage is an option to reduce cost and waste associated with harvesting and feeding hay. The cost of hay and purchased feed for winter feeding is the largest expense of maintaining a livestock herd (Jennings et al., 2009).

Not every forage has the ability to withstand stockpiling; the species has to be considered. Tall fescue and orchardgrass are cool-season perennials that are often stockpiled, but tall fescue has been shown to have better results when grazed. Bermudagrass and bahiagrass are warm-season perennials that are often stockpiled; however, the nutritive quality is less than that of tall fescue (Ball et al., 2015). Bermudagrass does produce a higher yield and maintains greater concentrations of CP and TDN value than bahiagrass (Hancock et al., 2011).

Bermudagrass varieties differ in seasonal production characteristics, which influences the amount of forage accumulated during a stockpiled period. Coastal bermudagrass has the ability to produce more biomass in the late summer and fall months and to maintain active growth later than common bermudagrass (Lalman et al., 2000). Lalman et al. (2000) stated that stockpiling does have a detrimental factor, which is the lodging of biomass during and subsequent to the stockpiling period. Stockpiling forage requires allowing the forage to grow and accumulate, which in turn means that the forage is allowed to reach maturity. In general, plant maturity is associated with protein concentration and DM digestibility (i.e., increase maturity, protein concentration and DM digestibility decrease). One of the contributing factors to declining protein concentration and forage digestibility with advancing maturity is the decrease in the proportion of leaves associated with advancing age (Lalman et al., 2000).

Jennings et al. (2009) reported in an extension article that on-farm demonstration samples of stockpiled bermudagrass in October contained 23.8% CP and 81% TDN. These same pastures were sampled in February and contained 6.5% CP and 48.8% TDN, illustrating a decline in quality as weathering increased. Wheeler et al. (2002) conducted a 2-yr study in Stillwater, Oklahoma and Haskell, Oklahoma to determine the nutritive value of fertilized stockpiled bermudagrass pasture during winter. The initial standing crop varied among location and year. In Stillwater, forage mass was 3,055 kg/ha and 2,106 kg/ha in Yr 1 and 2, respectively. In Haskell, forage mass was 3,717 kg/ha and 4,546 kg/ha in Yr 1 and 2, respectively. The overall average was 3,360 kg/ha. Masticate samples from Stillwater were collected from four 2-yr-old Angus × Hereford esophageally fistulated heifers and used to determine chemical composition; NDF (56.4 to 68.0% DM in Yr 1 and 60.6 to 64.6% DM in Yr 2) and ADF (30.3 to 38.0% DM in Yr 1 and 30.5 to 38.9% DM in Yr 2) concentration increased from November through January whereas TDN decreased during the same time period (53.9 to 38.0% DM in Yr 1 and 48.4 to 43.3% DM in Yr 2). Crude protein concentration decreased during the stockpiling period (13.1

to 11.0% DM in Yr 1 and 15.3 to 11.6% DM in Yr 2); however, values remained close to the dietary concentration recommended for gestating beef cows (Wheeler et al., 2002).

McNamee (2014) conducted a 2-yr study to determine effects of rate of N fertilization on productivity and nutritive value of stockpiled Tifton 85 for lactating cow and calf performance. Mean forage accumulation was 6,190 kg/ha and 4,207 kg/ha for Yr 1 and Yr 2, respectively. The mean CP concentration declined over the grazing period (late October to mid-January) from 16.0 to 10.0% DM in Yr 1 and from 16.6 to 9.7% DM in Yr 2. The NDF concentration in Yr 1 (66.1 to 70.0% DM) and Yr 2 (65.3 to 69.0% DM) and the ADF concentration in Yr 1 (30.1 to 34.7% DM) all increased over the grazing period, but the ADF concentration in Yr 2 maintained a similar level throughout the grazing season (32.1 to 31.7% DM) over the grazing period. The IVDMD concentration declined over time in Yr 1 (68.1 to 52.6% DM) and Yr 2 (67.5 to 51.1% DM), illustrating a decrease in overall digestibility of standing forage with increasing length of the stockpiled grazing period.

Hay Production

Hay is often used during the winter in the Southeast to help overcome the forage deficit. Hay is defined as harvested forage preserved by drying generally to a moisture content of less than 200 g kg^{-1} DM (Allen et al., 2011). The use of hay has some advantages; such as it can be mechanized, it stores well if adequately protected, and it can meet the nutritional requirements of most classes of livestock (Ball et al., 2015). Hay can also be a means of managing surplus or excess forage that cannot be used during the active growing season. Disadvantages associated with hay production potentially may be cost, labor, storage and feeding losses. Estimates in 2009 showed combined costs of producing and harvesting hay were at least $25 per round bale (Jennings et al., 2009).

Species consideration is needed in quality hay production. In most cases it is more economical to use a perennial grass for hay to eliminate the cost of having to plant or establish forage on an annual basis (Ball et al., 2015). When using hay in any livestock system, quality is the most important factor. The energy and protein value of the hay need to be determined. The best way to obtain the most accurate measurement of hay quality is through forage testing. Stage of maturity at harvest is the most important factor controlled by the producer. The stage of maturity at harvest influences the palatability, CP concentration and especially the digestible energy concentration (Ball et al., 2015). Hay storage also can influence the quality of the hay. Protection from weathering helps reduce the loss of quality and chances of spoilage. Use of a hay barn or simply placing hay under shelter can help protect and reduce loss (Ball et al., 2015).

Mandebvu et al. (1999) compared Tifton 85 bermudagrass hay with Coastal bermudagrass hay harvested after 3, 5, and 7 wk of regrowth (vegetative stage of growth, nonflowering stems) and reported that Tifton 85 had greater concentrations of NDF, ADF, hemicellulose and cellulose, lower concentrations of ADL, and greater IVDMD than Coastal bermudagrass. The authors also reported that the intake of DM, OM, CP and NDF of the beef steers consuming the hay were similar, but the steers consuming the Tifton 85 hay had greater digestion of these components than the steers consuming the Coastal bermudagrass hay. Tifton 85 may offer hay production potential late in the establishment year, whereas most cultivars do not produce enough forage for hay production or grazing until the second year. Tifton 85 hay consistently had greater *in vitro* and *in vivo* digestibility than Coastal or Tifton 78 hay, even when NDF of the Tifton 85 hay was above 70% (Hill et al., 2001).

Burns and Fisher (2007) conducted a 2-yr study evaluating the dry matter intake (DMI) and digestion of Coastal (CB), Tifton 44 (T44) and Tifton 85 (T85) bermudagrass hays using sheep. They reported in Yr 1 that DMI was greatest for CB (2.05 kg 100kg^{-1} BW) compared with the mean of T44 (1.70 kg 100kg^{-1} BW) and T85 (1.71 kg 100kg^{-1} BW). In Yr 2, the DMI of the three cultivars did not differ. In Yr 1, the IVDMD and CP concentrations were least and NDF, hemicellulose, and lignin concentrations greatest for CB compared with the mean of T44 and T85. Tifton 85 had the greatest IVDMD, ADF, and cellulose concentrations compared with T44. Similar results were reported in Yr 2, illustrating the nutritive value of Tifton 44 and Tifton 85 bermudagrass hays in the described study.

SUPPLEMENTATION STRATEGIES

Protein Supplementation

Defining RDP and RUP

Kunkle et al. (2011) stated that producers may feed supplements to beef cattle consuming forage-based diets to correct for nutrient deficiencies, conserve forage, improve forage utilization, improve animal performance and potentially increase economic return. In the present study, supplementation of stockpiled warm-season forages may be required to support a target level of animal performance (average of 1.0 kg/head/day). While many factors go into determining a supplementation program, the first step is to determine the first limiting nutrient in the animal's diet, which can be, but not limited to, a mineral, energy or protein (Klopfenstein, 1996).

Protein supplementation can provide needed nutrients in the form of rumen degradable protein (RDP), rumen undegradable protein (RUP), or a combination of both. Klopfenstein (1996) defines RDP as protein that is degraded in the rumen and used by microbes as a source of nitrogen to produce microbial protein. Microbial protein is produced by the rumen microbes from the rumen degradable protein and is utilized by the animal. Depending on the efficiency of synthesis, this can supply as much as 50 percent to all of the metabolizable protein required by beef cattle, which largely depends on class and stage of production (NRC, 2000). The authors also define RUP as protein that escapes the rumen largely unaltered and is digested primarily in the small intestine. In order for a response to escape protein to be effectively realized, the degradable protein requirements for microbial growth must be met first (Klopfenstein, 1996).

Metabolizable protein is defined as the amount of true protein that arrives in the intestine of the cow and is supplied by two sources: the true protein in the diet that escapes degradation in the rumen (RUP) and the bacterial protein produced by the rumen microbes (i.e. microbial protein; Block, 2006). This source provides the needed supply of amino acids to the animal for biological functions (Block, 2006).

When determining if supplementation is required, the forage base being utilized must be considered and its nutritional value compared to daily animal requirements. There are often notable differences between cool-season and warm-season grasses with respect to protein concentration and degradability characteristics. Akin (1989) stated that warm-season grasses tend to be more slowly degraded in the rumen than cool-season grasses. When rate of passage is slowed, protein in warm-season grasses may escape the rumen for potential to be degraded in the small intestine. In a similar evaluation, Karges et al. (1992) concluded that when rate of passage is considered, the amount of metabolizable protein contributed by warm- and cool-season grasses may not be the same. Klopfenstein (1996) noted that RUP often needs to be supplemented at some level to a growing animal grazing forage because the protein in both cool-season and warm-season grasses is highly degraded.

Karges et al. (1992) investigated whether a deficiency exists for ruminally degradable protein and/or escape protein in yearling steers grazing native summer range (average crude protein was 10.8% in year one and 9.4% in year two) and determined that steers supplemented with RUP as well as RDP resulted in a linear increase in ADG. The degradable protein supplemented was a mixture of corn steep liquor (92.6% DM) and urea (4.9% DM). The RUP supplement was a mixture of heat treated soybean meal (67.9% DM) and feather meal (24% DM). The RUP supplementation levels were 0.17 kg/d, 0.34 kg/d, 0.52 kg/d. Along with the RUP supplement, RDP was additionally supplemented at levels of 0.53 kg/d, 0.45 kg/d and 0.36 kg/d, respectively. The resulting ADG was 1.08 kg/d, 1.05 kg/d and 1.12 kg/d, respectively. Anderson et al. (1988c) also observed that with increasing levels of RUP supplementation to steers grazing smooth bromegrass that animal performance increased. The RUP supplemented was a mixture of bloodmeal (33.2% DM) and corn gluten meal (44.8% DM). The levels of supplementation were 0 kg/d, 0.11 kg/d, 0.23 kg/d, and 0.34 kg/d, resulting in ADG of 0.89 kg/d, 0.94 kg/d, 1.06 kg/d, and 1.01kg/d, respectively.

There are many different types of protein supplements that can be used in beef cattle diets. A protein supplement is defined as a feed or mixture of feeds containing at least 20% crude protein (Wright and Lackey, 2008) and are highly digestible. When selecting an appropriate protein supplement for grazing cattle, feed availability, cost per ton, as well as cost per pound of nutrient provided, should be taken into consideration. Meals are often used for supplementation of RUP. This is because meals are often finely ground, which increases the surface area and decreases the particle size so it can easily escape the rumen without being altered and make its way to the small intestine for degradation and utilization (Russell, 2002). Some protein supplements that are commonly used in the industry today include corn gluten meal, meat and bone meal, blood meal, hydrolyzed feather meal, fish meal, soybean meal, cottonseed meal and dried distiller's grains (Horner and Sexton, 2015). These sources are typically animal or grain-based co-products.

Cottonseed Meal

In the Southeast, cottonseed meal is an excellent RUP supplement. Cotton is a major row crop in this region, leading to an increased availability of this co-product that is easily obtained. The average cost is $305 per ton (Horner and Sexton, 2015) and it is about 41 to 43% crude protein (NRC, 2000), making it cost approximately 38 cents per pound of protein on a dry matter basis.

McCollum and Galyean (1985) observed that supplementing steers with cottonseed meal increased the rate of passage of particulates, which contributes to increased voluntary intake of a low quality (6% crude protein) prairie hay. Hunt et al. (1989) conducted a study comparing a control diet feeding only low-quality hay (6.6% crude protein) with a diet supplemented with cottonseed meal fed at three different time increments: 12 hours, 24 hours and 48 hours to provide 3 g CP/kg $BW^{0.75}$ daily to growing steers. The authors noted that steers supplemented with cottonseed meal had greater DM and NDF intake than those fed the control diet, which suggests that the supplemented group had greater total hay consumption. Cottonseed meal supplemented diets had a 86% faster particulate passage rate than the unsupplemented, which means less was digested in the rumen and more is available for degradation in the small intestine (Hunt et al., 1989). Hunt et al. (1989) concluded that cottonseed meal supplementation improves forage utilization of low-quality grass hay, which leads to the concept that cottonseed meal supplementation can also improve forage utilization of low-quality forage. Cottonseed meal has potential to be used as a supplement with stockpiled forage to improve the forage utilization.

Energy Supplementation

Definitions and Common Sources in Southeast

Energy supplements are based on the percent of total digestible nutrients (TDN), and typically supplements have at least 70% TDN. However, protein supplements also contain TDN that must be considered when determining supplemental strategies. Energy supplements may contain carbohydrates (nonstructural and/or structural), lipids and protein. The type of carbohydrate has effects on the rate and extent of forage digestion in beef cattle diets (Bowman and Sanson, 1996). When supplementing with nonstructural carbohydrates such as cereal grains on low-quality forage, intake and digestibility often decrease. When supplementing with structural carbohydrates from fibrous by-product feedstuffs on low-quality forage, DM intake and forage utilization have been shown to increase (Winger et al., 2006). Nonstructural carbohydrate-based supplements, like cereal grains, have generally reduced forage intake more than sources of highly degraded fiber like wheat middlings, beet pulp, and corn gluten feed (Caton and Dhuyvetter, 1997). Nonstructural carbohydrate-based supplements typically refer to starchy supplements. Anderson et al. (1988a) concluded that rolled corn or whole soyhulls as energy supplements increased daily gain of steers grazing bromegrass in the fall with ADG of 1.13 kg/d for the whole soyhulls supplemented steers and 1.14 kg/d for the rolled corn supplemented steers, whereas the non-supplemented steers achieved an ADG of 1.04 kg/d. Anderson et al. (1988b) conducted a second experiment and concluded supplementation of energy with either corn, ground soyhulls and whole soyhulls increased daily gain over the summer grazing period, with the corn achieving an ADG of 0.75 kg/d, 0.77 kg/d for ground soyhulls and 0.78 kg/d for whole soyhulls. Non-supplemented cattle achieved an ADG of 0.60 kg/d, illustrating the enhanced gain potential when energy is supplemented.

Energy supplements commonly used in the Southeast are often cereal grains or co-products of the row-crop/milling agricultural sectors. Cereal grains largely provide energy in the form of nonstructural carbohydrates and are high in starch and sugar. One of the most common grains used in supplementation programs in the Southeast is corn. Co-products often provide a source of structural carbohydrates and are high in fiber (Sanson, 1995). These supplements may provide a lower-cost alternative to cereal grains. Common co-product feeds available in the Southeast include soybean hulls, wheat middlings, citrus pulp, corn gluten feed, beet pulp and dried distiller's grain.

Horn and McCollum (1987) concluded that energy supplements reduce forage intake as well as digestibility when fed at higher levels. To improve the relationship among forage intake, digestibility and energy supplementation, producers can feed energy supplements at lower levels over a longer period of time when available forage supply is good. Producers should implement the previous stated action over feeding energy supplements at higher levels when forage nutrients are nearly depleted (Kunkle et al., 2000).

Soybean Hulls

Soybean hulls are a co-product of soybean processing and often chosen to provide supplemental energy in cattle diets in the Southeast due to availability and cost. Prices fluctuate seasonally, but average $140 per ton (Horner and Sexton, 2015). They are highly digestible and very palatable to beef cattle. Soybean hulls have about 2.89 Mcal/kg ME and 1.94 Mcal/kg NE with an 80% TDN on a dry matter basis (NRC, 2000).

Anderson et al. (1988a) conducted a study to evaluate the use of whole soybean hulls as an alternative to rolled corn for energy supplementation of cattle grazing fall smooth brome pastures. Corn and soyhulls were fed at a rate of 1.36 kg DM/hd/d in portable feed bunks. The authors observed that soybean hulls and corn were similar in energy value. In the second trial, they included ground soybean hulls and noted that there was no difference in the average daily gains among animals (steers and heifers) fed corn, ground soybean hulls or whole soybean hulls. Based on these evaluations, Anderson et al. (1988a) concluded that soybean hulls contain greater amounts of digestible fiber than corn, but still support a similar level of average daily gain. Using soybean hulls may entail a reduced chance of acidosis and provide an alternative to starch-based energy supplementation. Martin and Hibberd (1990) evaluated the effect of feeding graded levels of soybean hull supplements (0, 1, 2, or 3 kg of soybean hull DM/hd were fed at 8 a.m. each day) on digestibility and intake of low-quality native grass hay by beef cows and found that native grass hay (4.1% CP) digestibility did not decline when supplemented with soybean hulls, which suggested that soybean hulls are not digested at the expense of forage. In corn-based supplementation systems, Chase and Hibberd (1987) observed decreased digestibility of low-quality native grass hay when corn was provided at the level of 1, 2 or 3 kg/hd/d. When compared to corn supplements, soybean hull supplements should increase energy intake without decreasing forage utilization by grazing beef cows (Martin and Hibberd, 1990). Based on these studies, when providing supplemental energy in warm-season forage systems, soybean hulls may provide an economical and effective supplementation strategy.

Supplementation Responses in Warm-Season Grazing Systems

Forage quality of warm-season grasses is generally much less than that of cool-season grasses; however, plant breeding and developments of hybrids are improving the quality of some warm-season forages (Ball et al., 2007). Implementing supplements into a feeding program for cattle grazing warm-season grasses is advised late in the production season as nutritive value begins to decline. Additionally, warm-season grass tissues tend to be degraded slower than cool-season grass tissue in the rumen (Akin, 1989).

Hafley et al. (1993) observed that steers grazing a mixed stand of big bluestem, switchgrass and indiangrass supplemented with escape protein, supported greater ADG than the non-supplemented steers. When steers grazing bermudagrass were supplemented with grain there was a general increase in the ADG compared to the steers grazing bermudagrass alone. When the steers were supplemented at 1% BW, ADG was greater for grain degraded in the rumen slowly (ground corn, whole corn and sorghum grain) than for grain degraded rapidly (barley and wheat) (Galloway et al., 1993a.)

When supplementing with corn or soybean hulls at a moderate level of digestible energy (20 kcal/kg of BW), similar increases in energy intake will be supported by growing ruminants consuming warm-season forage because of their differences in forage intake and fiber digestibilities (Galloway et al., 1993b). Aiken (2002) conducted a study comparing rates of supplementation with ground corn on bermudagrass pastures by growing steers and reported that there was a strong curvilinear increase in ADG with increased levels of supplemented corn. The levels were 0, 0.45, 1.35 and 2.25 kg steer^{-1}d^{-1}, which resulted in an ADG response of 0.84, 0.98, 1.15 and 1.16 kg d^{-1}, respectively. Aiken (2002) noted that steer performance consistently increased between the 0 and 1.35 kg steer $^{-1}$d^{-1} rates, and stabilized between and the 1.35- and 2.25-kg rates.

COOL-SEASON GRASSES

General Overview of Adapted Species to Southeast

Cool-season forages experience most of their growth during the coolest months of the year (October through March in South Alabama), excluding the coldest periods of winter (Ball et al., 2015). Cool-season grasses can be categorized as annuals or perennials. Orchardgrass (*Dactylis glomerata*) and tall fescue (*Festuca arundinacea*) are the most common cool-season perennials found in the Southeast. Annual ryegrass (*Lolium multiflorum*) and small-grain rye (*Secale cereal*), wheat (*Triticum aestivum*), oats (*Avena sativa*), and triticale are also used extensively within this region (Ball et al., 2015). Cool-season species are generally higher in nutritive value than warm-season grasses, with the overall digestibility of cool-season grass species averaging about 9% higher than warm-season grasses (Ball et al., 2001). Ball et al. (2001) stated that due to differences in leaf anatomy (tissue arrangement or structure), warm-season grasses convert sunlight into forage more efficiently than cool-season grasses, but their leaves contain a higher proportion of highly lignified, less digestible tissues.

Small Grains

Rye

Rye is more commonly known as a grain crop that is mixed with wheat flour for the purpose of bread making; however, less than 50% of the rye grown in the U.S. is harvested for grain, with the remainder used as pasture, hay or as a cover crop (Oelke et al., 1990). Since the 1950s, stocker cattle producers in the southern U.S. have been largely dependent on the cool-season annual cereal grasses; mainly rye and wheat, for grazing from fall to spring (Ball et al., 2015).

Rye is a small grain that will only grow to be 2 to 4 feet tall. It is commonly used in grazing systems and is more tolerant of soil acidity than other small grains. It is known for its drought tolerance and winter hardiness (Ball et al., 2015). Bruckner and Raymer (1990) conducted a study comparing small-grain species for winter production evaluating average and potential yield, dependability of production, seasonal forage distribution and cold tolerance. They concluded that, as a species, rye had the most uniform seasonal forage production pattern, producing 36, 26, and 38% of its total forage in early, mid-, and late-season periods, respectively, and the lowest minimum temperature requirement for growth at 0°C (Bruckner and Raymer, 1990), which makes rye a desirable choice for winter grazing systems by many producers in colder climates. Rye is planted on an annual basis, usually in September to October, depending on if it is being planted into a prepared seedbed or overseeded (Johnson and Ball, 2013).

Bruckner and Raymer (1990) concluded that rye is more suitable for grazing systems than other small grains due to its greater forage production, especially during the winter months. The authors also determined that rye has excellent forage quality (~120 g crude protein kg^{-1} DM and 700 g *in vitro* dry matter digestibility kg^{-1} DM), which is sufficient for growing cattle (NRC, 2000).

Beck et al. (2005) conducted a 3-year study on stocker cattle grazing small grains grown alone or in combinations in Arkansas, and reported that ADG (1.11 kg/d) from rye over the 3-year period did not differ between fall-winter (generally October to January) and spring (generally March to May) grazing seasons. The average total gain/ha from the rye was 645 kg over the 3 years (Beck et al., 2005). Beck et al. (2007) evaluated cool-season annual grasses overseeded into a bermudagrass sod for stocker cattle and observed that rye produced the greatest ADG in spring (1.17 kg/d) among all the species tested. In this study, rye supported 560 grazing-days/ha.

Some commercially available rye varieties in the Southeast include Bates RS4, FL 401 and Wrens Abruzzi. FL 401 characteristically has high early-season forage production, but low mid-, late-, and total-season production (Bruckner and Raymer, 2013). However, it is a commonly recommended early maturing variety in the region (Hancock, 2015). Early-maturing varieties may be used to support gain by the grazing animal, and row crop producers tend to use these varieties as a cover crop because they have completed their life cycle by the time the producers are ready to till and plant their succeeding crop. Producers may use a later maturing variety when trying to extend the production season of what may be planted as a companion crop for grazing purposes.

Oats

Oats are a commonly used grain for human consumption in breakfast cereals and granola. However, over 95% of oats grown in the U.S. are used for livestock purposes for feed such as grain, pasture, hay or silage (Nicholas, 2009). Oat is a small grain that is often grown across the U.S., but has greater productivity in the lower South due to its greater cold sensitivity than other small grains, which makes it susceptible to winterkill (Ball et al., 2015). It is an annual, so planting every year is necessary for use. Planting should occur in the months of September or October in the Deep South.

Bruckner and Raymer (1990) found that oats had the least uniform seasonal forage distribution, producing 42%, 12% and 46% of its total forage production in early, mid- and late-season periods, respectively. However, all oat cultivars were high-yielding in early-season production (Bruckner and Raymer, 1990). Beck et al. (2005) conducted a 3-year study on stocker cattle grazing different small grains grown alone or in mixtures in Arkansas, and reported that ADG from oats was greater in the fall-winter (1.13 kg/d) than the spring (1.02 kg/d) grazing period. However, oats experienced winterkill in year 2 of the study, so the spring grazing period of oats in year 2 did not occur, decreasing the ADG potential of the overall spring grazing period. Beck et al. (2007) later evaluated cool-season annual grasses planted into a bermudagrass sod for stocker cattle and observed that oats produced a winter ADG of 0.42 kg/d and a spring ADG of 1.10 kg/d. However, oats supported 535 grazing-d/ha, which was the least among all of the species tested. Some of the most productive commercially available oat varieties in the southeast include Horizon 201, RAM LA99016 and SS 76-50 (Hancock, 2015).

Ryegrass

There are two species of ryegrass used in the U.S., perennial ryegrass (*Lolium perenne*) and annual ryegrass (*Lolium multiflorum*). Annual ryegrass is well adapted to the growing conditions of the Southeast, with the ability to tolerate wet, poorly drained soils and relative tolerance of close grazing (Johnson and Ball, 2013). Annual ryegrass is considered to be one of the highest quality winter forages utilized in the southeastern U.S. Dry matter digestibility is generally greater than 65% and CP concentration exceeds the requirements for most classes of livestock animal gains (Blount and Prine, 2012). Annually, more than one million hectares of annual ryegrass are grown in the Southeast, from eastern Texas and Oklahoma to the southern East Coast. It has become an important component in winter forage-livestock systems (Blount and Prine, 2012). Ryegrass is mainly used as a grazed forage crop, but can be used for hay or silage. It should be planted in the months of September to October (Johnson and Ball, 2013). During the past 50 years, the use of annual ryegrass has expanded significantly, and many recommended cultivars currently commercially available include: 'Attain', 'Big Boss', 'Diamond T', 'Earlyploid', 'Fria', 'Jackson', 'Marshall', 'Nelson', 'Prine', 'TAMTBO' and 'Winterhawk' (Hancock, 2014).

Ploidy Levels

Annual ryegrass has historically been a diploid species; however, newer tetraploid varieties with twice as many chromosomes are becoming more available. Tetraploids have an increased cell size due to having more chromosomes per cell and a higher ratio of cell contents, such as soluble carbohydrates, in relation to cell wall constituents, indicating a higher water content per cell (Cosgrove et al., 1999). Diploid plants have more tillers per plant and lower water content per cell, thus a higher dry matter per kg of feed. While similar in protein levels, diploid tend to have a greater energy value. Tetraploids often have larger tillers, seed heads and wider leaves. They tend to be taller and less dense and are bred for greater disease resistance. While yields are similar between types, tetraploids lack the winter hardiness of the diploid varieties (Cosgrove et al., 1999). Some commonly recommended tetraploid annual ryegrass varieties in the Southeast are 'Nelson', 'Big Boss', 'Big Daddy' and 'Jumbo'. There are many commonly recommended diploid annual ryegrass varieties in the Southeast that include, but are not limited to, 'Florida 80', 'Fantastic', 'Gulf', 'King', 'Ribeye', 'Sirloin', 'Florina', 'Graze-N-Go', 'Jackson', 'Magnolia', 'Rio', 'Stampede', 'TAM 90', 'Marshall', 'Passerel' and 'Passerel Plus' (Blount and Prine, 2002). One variety that stands out for potential use in a stocker-row crop system is 'Earlyploid' tetraploid ryegrass. This variety is a commercially available earlier forage-producing tetraploid ryegrass that exhibits comparable seasonal yield and improved disease resistance to other ryegrass varieties (Blount et al., 2013).

Early vs. Late Maturing Types

Ryegrass cultivars can also be characterized by their maturation period. Maturity has the greatest effect on nutritive value. As plants mature, cell walls become more lignified and they constitute a larger proportion of the cell, resulting in an overall decrease in digestibility and CP concentration (Ball et al., 2015). Other than the physiological meaning of maturity, it also has a morphological meaning. The morphological meaning of maturity is the period of time when the plant begins to grow and seed out. As expected, early maturing varieties early in the season, while late maturing varieties mature later in the season. Selection of variety by maturity is highly dependent on when forage is needed. Early maturing provides forage before the later maturing types and the later maturing types will provide forage towards the end of the grazing season.

'Attain', 'Big Boss', 'Diamond T', 'Earlyploid', 'Jackson', 'Marshall', 'Nelson', 'Prine' and 'TAMTBO' are early-maturing recommended varieties. 'Gulf' is characterized as early to mid-maturing. 'King', 'Ribeye' and 'Sirloin' are described as mid-maturing. 'Big Daddy', 'Florina', 'Graze-N-Go', 'Jackson', 'Magnolia', 'Rio', 'Stampede' and 'TAM 90' are all characterized as mid to late-maturing. 'Marshall', 'Nelson', 'Passerel', 'Passerel Plus', 'Prine' and 'Jumbo' are all considered late-maturing (Blount and Prine, 2002,Blount et al., 2014). Redfearn et al. (2002) conducted a study to quantify differences in forage yield, distribution and nutritive value among 'Gulf', 'Rio', 'Surrey', 'Jackson', 'Marshall', 'Nelson' and 'Rustmaster' cultivars of annual ryegrass. The authors reported that approximately 40% of the total forage production occurred from December to February (early-season) and 60% accumulated from March to May (late-season). 'Jackson' and 'Marshall' produced 243 kg ha^{-1} more forage in April and May than 'Gulf'. However, 'Gulf' had greater early-season forage production than 'Marshall', which had a greater proportion of the production concentrated during the latter part of the growing season (Redfearn et al., 2002). CP differences among cultivars were observed in April, with a range in values of ±14 g CP kg^{-1} DM. 'Gulf', 'Jackson', 'Marshall', 'Rio', 'Rustmaster' and 'Surrey' had CP concentrations in g kg^{-1} of 172, 175, 178, 184, 170 and 183, respectively. Early-maturing ‘Rustmaster’ and ‘Gulf’ had the lowest CP values in April (Redfearn et al., 2002), which may be because protein concentration declines as plant maturity increases. Hafley (1996) conducted a study comparing ‘Surrey’ and ‘Marshall’ ryegrass by managing the pastures with both rotational and continuous grazing using yearling steers. The authors observed no differences in CP concentration between the grazing management; however, overall the CP concentrations ranged from 11.1 to 27.0% throughout the grazing season. Late-maturing ryegrass cultivars had a greater CP concentration at the end of the grazing season than with the early-maturing cultivars due to more vegetative growth among late-maturity types.

Mixtures

With its high yield potential and high nutritive value, ryegrass is an excellent choice for the winter grazing season. Annual ryegrass is often grown in mixtures with small grains that differ in their respective growth patterns to extend the grazing season (Mullenix et al., 2012). Beck et al. (2005) reported that ADG from rye-ryegrass mixtures was greater in the spring-grazing than fall-winter grazing period (1.32 kg/d and 1.20 kg/d, respectively). The ADG from the mixed pastures of wheat and annual ryegrass in the fall-winter grazing and spring-grazing did not differ with them both producing 1.24 kg/d. When animal performance was evaluated for steers grazing a combination of wheat, rye and annual ryegrass, Beck et al. (2005) observed 1.21 kg/d ADG in the fall-winter and 1.12 kg/d an ADG in the spring grazing period. Overall, rye-ryegrass mixtures supported the greatest average gain per hectare (Beck et al., 2005). Mullenix et al. (2012) conducted a study that compared beef cattle performance from small-grain/ryegrass mixtures and reported that oats mixed with ryegrass generated the highest ADG of 1.38 kg/d, while rye and ryegrass mixtures only generated 1.13 kg/d. Myer et al. (2011) noted that blending ryegrass with cereal grains resulted in longer grazing periods, increased forage yields, greater gain per ha and increased grazing days, making blends a desirable forage option for stocker production systems.

GRAZING MANAGEMENT

Definition/Background/Importance

Forage production, dry matter intake, digestibility and grazing behavior itself are all affected by grazing management (Prigge et al., 1997). Grazing management is defined as the manipulation of grazing in pursuit of a specific objective or set of objectives (Allen et al., 2011). There are two general categories for grazing management, which are related to extensive or intensive management strategies. Extensive grazing management is the use of relatively large land areas per animal and relatively low levels of labor, resources or capital (Allen et al., 2011). Intensive grazing management is the use of relatively high levels of labor, resources or capital to increase production per unit area or per animal, through a relative increase in stocking rates, grazing pressure and forage utilization (Allen et al., 2011). Intensive grazing is the practice that is most commonly recommended in the Southeast.

Forage Allowance

Forage allowance (FA) is defined by Allen et al. (2011) as the relationship between forage mass and animal live weight per unit of the specific unit of land being grazed at any one time; an instantaneous measurement of the forage-to-animal relationship. The relationship between daily gain and forage allowance is linear up to some relatively high allowance, after which gain levels off (McCartor and Rouquette, 1977). Forage allowance can be determined by the following equation (Sollenberger et al., 2005):

FA = forage mass (kg DM/ha) / total animal live weight (kg) = kg forage DM/kg animal BW

The previous equation requires the first step of determining the paddock size needed to support a given number of animals, which can be calculated by the following equation:

Ha required/paddock =[(BW,kg) × (DMI,% of BW) × (number of animals) × (d/paddock)] / [(available DM, kg/ha) × (% utilization)].

However, this requires estimates of forage utilization and the regrowth period (Sollenberger et al., 2005).

Forage Utilization and Methods (Frontal Grazing)

Forage utilization is defined as the percent of the forage that the animal consumes. The percent utilization can vary depending on the type of grazing management method used. After the total area available to be grazed is determined, the number of animals needed to utilize the available forage can be calculated by the following equation:

Number of animals required to graze a paddock= [(kg forage DM/ha) × (ha) × (% utilization)] / [(kg animal weight) × (DMI in % of BW) × (d)].

Then the number of animals is used to calculate the number of days the forage is expected last using the following equation (Sollenberger et al., 2005): [(kg forage DM/ha) × (ha) × (% utilization)] / [(kg animal weight) × (DMI in % of BW)] × (number of animals).

There are many different grazing management practices used, specific goals and objectives contribute to which grazing method is selected by the producer. Some of those goals include: improve grazing efficiency, reduce pasture waste, conserve surplus forage (i.e. hay or silage), increase animal performance and improve forage quality at time of use. Contributing objectives include managing forage quantity and quality effectively over the growing season, and improving grazing efficiency and animal production per unit area of land (Johnson and Mullenix, 2014). Just like with any farm, the grazing method used will be different from operation to operation, due to different needs and availability of resources. Some grazing methods utilized in the Southeast include: continuous stocking, rotational stocking, creep grazing, first-last grazing, strip grazing, frontal grazing or limit grazing. Each method has its own advantages and disadvantages. Overall, continuous stocking is estimated to have the lowest efficiency, whereas strip grazing has the greatest estimated harvest efficiency (Johnson and Mullenix, 2014). In a study conducted by Hafley et al. (1996), cattle that continuously grazed annual ryegrass gained faster than rotationally grazed steers; however, the rotationally grazed steers produced more total pounds of beef per unit of land grazed. Stocker cattle should gain as fast as possible to make the most advantage of inexpensive gains from grass. Aiken (2016) stated that the use of either continuous or rotational stocking methods will depend on whether recommendations from research should complement a standard grazing method used by forage-based productions or if the objectives of the research are to determine best management practices.

When stockpiling, effective forage utilization is dependent on proper grazing method. Continuous stocking will result in a high percentage of the forage being trampled and wasted (Ball et al., 2015). Ball et al. (2015) have stated that strip grazing with the use of a movable electric fence is a useful way to ration daily forage allowance for cattle to reduce waste. Strip grazing is a method that confines animals to an area of land to be grazed in a relatively short time, where the paddock size is varied to allow access to a specific land area (Allen et al., 2011). This method results in high forage utilization and is most effective during cool weather when nutritive quality declines slowly (Ball et al., 2015). In Arkansas on-farm demonstrations, Jennings et al. (2009) showed that strip grazing management doubled the number of grazing days per acre compared with continuous grazing of stockpiled pastures.

Frontal grazing is a method that allocates forage within a land area by means of a sliding fence that can be advanced to gain access to ungrazed forage (Allen et al., 2011). This method is most commonly used when stockpiling forage. When using this particular method the forage is often in a dormant stage; therefore, there is no need to limit access to previously grazed area. When moving the adjustable fencing, only allow animals enough access to forage that will meet their certain nutritional requirements for 2 to 3 days (Johnson and Mullenix, 2014). Because this method coincides with stockpiling, tall fescue and bermudagrass are the two most common forages in the Southeast used for this grazing method. This method does require more labor than some of the other methods, but labor is not extensive and it is advantageous in that the animals are receiving more attention than if in a continuous grazing situation.

Fixed vs. Put-and-Take Stocking Strategies

There are many different types of stocking strategies and the type used is dependent upon many factors. Aiken (2016) stated that stocking rate has a profound effect on animal performance and has been the primary management tool used by producers in targeting production. Allen et al. (2011) defines put-and-take stocking as a method of using variable animal numbers during a stocking period or stocking season, with a periodic adjustment in animal numbers in an attempt to maintain desired management criteria (i.e., desired quantity of forage, degree of defoliation or grazing pressure). Fixed stocking means the use of uniform stocking rates during all periods of a grazing season (Marten and Jordan, 1972). Put-and-take stocking has an advantage over fixed in the aspect that it adjusts stocking rate to changes in forage growth patterns. This allows determinations of an optimum grazing pressure and a comparison of steer performance and productivity at a controlled grazing pressure; however, the errors in adjusting stocking rate can bias the data. Fixed stocking rate also has its advantages over put-and-take in the aspect that it allows grazing pressure to be the response variable and provides an analysis of the treatment × stocking rate interaction. This interaction may provide comparisons in treatment responses to stocking rate, but an optimum stocking rate cannot be determined (Aiken, 2016).

OVERVIEW OF RESEARCH PROBLEM

In the Coastal Plain region, stocker producers face a fall forage gap between summer perennial grasses and winter annuals. In the fall in south Alabama, summer perennial grasses are decreasing in quantity and nutritive value, whereas winter annuals are typically not ready to be grazed until late December to early January. This period corresponds with the time that a stocker cattle producer typically purchases calves. Traditional efforts to close the forage production gap have been costly. Historically, feeding hay or hay and co-product supplement during this time helped overcome the forage gap. Stockpiling warm-season forage can potentially be an option. Bermudagrass, especially Tifton 85, has been shown to maintain good production and nutritive value characteristics into the fall. Stockpiling supports the concept of extending the grazing season on warm-season grasses. In addition to grazing the stockpiled forage, supplemental feedstuffs may also be needed to help animals maintain a desirable level of animal performance. Studies have shown that providing supplemental energy and protein to animals grazing low-quality warm-season grasses can increase animal performance. Whereas bermudagrass has been shown to be relatively high in rumen degradable protein, supplementation with by-products that are high in rumen undegradable protein and energy may help better balance the nutrient requirements of grazed stocker cattle. After the stockpiled forage is depleted, it is expected that the winter annual forage will be ready for grazing. The winter annuals in the Deep South are often planted as part of a cover cropping system. The goals of the cool-season grazing management portion of this project are to evaluate differences in forage productivity and animal performance between mixtures containing an early maturing ryegrass (February to March) vs. a late maturing ryegrass (March to April), or an early-producing small-grain mixture. Few farmers use ryegrass as a cover crop simply because of the late maturity, which cuts into the producers planting time. The effort and cost to kill and till the cover crop area currently outweighs the advantage of using ryegrass. Our goal is to identify forage varieties that do not cut significantly into the planting establishment window for row crop producers.

II. BEEF STOCKER STEER PERFORMANCE, FORAGE PRODUCTIVITY AND QUALITY FROM STOCKPILED TIFTON 85 BERMUDAGRASS

INTRODUCTION

Bermudagrass (*Cynodon dactylon* L.), a warm-season perennial forage, is one of the major forage species used for sustaining beef cattle production systems in the Southeast. Bermudagrass stands can persist and remain productive for more than 35 yr if properly managed, and it is an especially popular forage in the southeastern US due to its tolerance of acidic and sandy soils, heavy grazing pressure, and variable rainfall distribution (Hill et al., 2001). Bermudagrass is suited for fall stockpiling; stockpiled forage is allowed to grow and accumulate for grazing at a later time, for use in winter-feeding, or during a period of forage deficit (Ball et al., 2015). Improved hybrid bermudagrasses provide superior yield potential, persistence, and quality compared with unselected ecotypes under this type of management (Hill et al., 2001).

Tifton 85 bermudagrass is an example of a commercial hybrid resulting from a cross of 'Tifton 68' and Stargrass (*Cynodon nlemfuensis L.*). 'Tifton 68' is a variety of hybrid bermudagrass that is highly digestible but cold susceptible (Burton et al., 1993). Stargrass is a plant introduction from South Africa. Tifton 85 was developed by the USDA-ARS in cooperation with the University of Georgia Coastal Plain Experiment Station, Tifton, GA and released in April 1992. It is taller, has larger stems, broader leaves and a darker green color than most other bermudagrass hybrids. Tifton 85 has large rhizomes and large, rapidly spreading stolons. It can be established by planting sprigs with mechanical planters or broadcasting and disking green stems cut at an advanced growth stage into moist soil (Burton et al., 1993).

Digestibility of NDF is also greater due in part to lesser concentrations of lignin and ethereal linkages between ferulic acid and cell-wall carbohydrates in Tifton 85 (Mandebvu et al., 1999).

The use of stockpiled bermudagrass can potentially reduce winter feeding costs in cow-calf operations, but few studies have been conducted with stocker cattle. The NRC (2000) suggests that the energy and protein requirements of growing animals may exceed that provided by stockpiled warm-season forage alone. However, stockpiling may provide an alternative to hay use prior to the availability of cool-season annuals for fall-purchased stocker cattle. For this reason, a late fall/early winter grazing study was conducted to determine the effectiveness of using stockpiled Tifton 85 bermudagrass with or without supplementation as a replacement for hay during the receiving period for growing steers.

MATERIALS AND METHODS

Experimental Site

All procedures and experimental protocols were approved by the Auburn University Institutional Animal Care and Use Committee (IACUC) (Protocol No. 2014-2519).

A 2-yr warm-season grazing experiment was conducted at the Wiregrass Research and Extension Center (WREC) in Headland, AL (31.35° N lat., 85.34° W long.) to evaluate the use of stockpiled Tifton 85 for backgrounding stocker cattle compared with feeding hay plus supplement during the fall forage gap. Six 0.75-ha paddocks of established Tifton 85 bermudagrass (*Cynodon dactylon L.*) were used for this portion of the experiment. The pasture area was used for hay production prior to the initiation of the experiment in August of each year and fertilized according to Auburn University Soil Testing laboratory recommendations. The soil type was a Dothan fine sandy loam (Fine-loamy, kaolinitic, and thermic Plinthic Kandiudults).

Experimental Design

A 2-yr grazing evaluation was conducted in the fall of 2014 (Yr 1) and 2015 (Yr 2). There were six 0.75-ha paddocks of stockpiled Tifton 85 (T85) and six 0.20-ha dry lot paddocks for feeding hay during the study. Treatments were arranged as a CRD with six treatments and two replications (n=12 total). Treatments included: T85 hay only (no supplement), T85 hay plus 0.2 kg cottonseed meal and 0.7 kg soybean hulls/head/day (65 g RUP/kg supplement CP) (25/75), and T85 hay plus 0.45 kg cottonseed meal and 0.45 kg soybean hulls/head/day (142 g RUP/kg supplement CP) (50/50). Stockpiled T85 treatments included: stockpiled T85 bermudagrass control (no supplement), stockpiled T85 plus 0.2 kg cottonseed meal and 0.7 kg soybean hull/head/day (65 g RUP/kg supplement CP) (25/75), and stockpiled T85 plus 0.45 kg cottonseed meal and 0.45 kg soybean hulls/head/day (142 g RUP/kg supplement CP) (50/50).

Animal Management

Seventy-five 250 kg steers were leased for the experiment and received in mid-September of both experimental years. Steers received a complete vaccination program against IBR, PI_3, BRSV, BVD, *Clostridia* spp., *Leptospira* spp., *Hameophilus somnus*, and *Pasteurella Haemolytica* and deworming program prior to arrival. Animals had free-choice access to Coastal bermudagrass pasture for a one month adaptation period prior to the start of the experiment. Steers were sorted and culled prior to the experiment based on body weight, temperament, and body condition score (BCS). Criteria for selecting treatment steers were a calm temperament, a BCS of 5 to 6, and a weight range of 214 kg to 263 kg in Yr 1 and a weight range of 186 kg to 284 kg in Yr 2. Treatment steers were randomly assigned to hay feeding paddocks or stockpiled Tifton 85 bermudagrass pastures (5 steers per treatment). Steers (initial BW 280 ± 38 kg) were assigned to treatments on November 11 and were removed on January 6 in Yr 1. In Yr 2, steers (initial BW 247 ± 21 kg) were assigned to treatments on October 28 and were removed from the study on December 21. In both years, steers were provided free-choice mineral mix (Formax 24/7, Alabama Farmer's Cooperative Inc., Decatur, AL) and water *ad libitum* throughout the study. In Yr 2, there were two paddocks [T85 hay only (no supplement) and stockpiled T85 bermudagrass control (no supplement)] that were removed from the study on December 4. Steers in these treatments fell below their initial receiving weights and BCS 4 to 5 following the first 28 d weigh period of the study.

Forage Management

Six 0.75-ha paddocks of established Tifton 85 bermudagrass were used in both years for stockpiling. In May of each year, paddocks received 56 kg N/ha, and P and K according to Auburn University soil testing recommendations. Pastures were harvested to a 10-cm stubble height every 28 days for hay production and received 56 kg N/ha following each harvest event. The hay produced from May until July was used as part of the hay plus supplement control treatment during this 2-yr study. Following the harvest in July, pastures were fertilized with 56 kg N/ha and 6 kg S/ha on August 15 in Yr 1 and with 56 kg N/ha and 9 kg S/ha on August 13 in Yr 2, and allowed to stockpile until initiation of grazing in mid-fall of each year (6 to 8 wks of accumulation). Throughout the grazing evaluation, pastures were managed using a frontal grazing approach. Polytape fencing was used in each paddock to allocate a 3 to 4 day allotment of forage DM for the animals based on 1) the available forage mass and 2) steer DMI requirements. Following the 3-to 4-day grazing period, the polytape fence was moved forward for the animals to have access to a new strip of forage to provide the equivalent forage mass needed to achieve the estimated DMI of 2.5% body weight (NRC, 1996) per animal unit and account for 30% loss due to trampling and waste effects.

Supplementation Management

The NRC (2000) indicates that energy and protein requirements of growing animals likely exceed that provided by stockpiled warm-season forage alone. Both cottonseed meal (CSM) and soybean hulls (SBH) are locally available sources of supplements. CSM was provided as a source of rumen undegradable protein, and SBH were provided to supply energy supplementation in the diet. Treatments assigned to supplementation strategies received 0.9 kg/hd/d of CSM/SBH mixture daily following initiation of the study on November 11 in Yr 1 and October 28 in Yr 2.

Animal Responses

During both years of study, test steers were weighed initially and then randomly assigned to their respective treatment group. Initial test weights were measured and recorded on the starting day of the study and were taken at 28-d intervals during the experimental period. Initial and final BW along with average daily gain were calculated and are reported in the results and discussion. Average daily gain (ADG) was calculated per animal by subtracting the initial weight before grazing from the final weight once cattle were removed from the experiment, divided by the total number of days the animal spent grazing or consuming hay. These values were then averaged per all animals in a paddock for analysis by treatment; paddock was the experimental unit.

Pasture Responses

Prior to the experiment and every two wk thereafter, stockpiled forage was sampled from six randomly selected locations within each paddock to determine forage mass and nutritive value. Once the experiment started, six randomly selected post-graze samples were taken in addition to the six randomly selected samples for the pre-graze part of the paddock. Samples were clipped from a 0.25-m^2 quadrat to a stubble height of approximately 5 cm, placed in cloth bags, and then transported back to Auburn University Forage Quality Laboratory for drying. Samples were dried to a constant weight in a forced air oven at 60°C. Samples were weighed for DM estimation and ground to pass through a 1-mm screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ) for nutritive value analysis.

Once the DM had been determined for samples, these estimations were used for calculation of forage allowance and percent utilization of the forage. Percent utilization was determined by the following equation: [(pregraze forage mass − postgraze forage mass) ÷

pregraze forage mass] × 100. Forage allowance was determined according to Sollenberger et al., 2005 as: (kg forage DM ÷ kg animal body weight per paddock). Herbage harvested was estimated as the pre-graze forage mass minus the post-grazing forage mass from a given sampling date.

In both years, forage samples were collected from the T85 hay used in the dry lot paddocks for analysis. Samples were collected with a Penn State hay probe in combination with a cordless drill (1.27cm and 24V). Six samples were obtained from randomly selected bales at initiation (November 11), mid point (January 16), and conclusion of the study (January 30) in Yr 1 and at initiation (October 28), mid point (November 24), and conclusion of the study (December 21) to provide a representative value for the quality of forage being fed.

After processing, all forage samples were scanned using a Perstorp Analytical 5000 near infrared spectrophotometer (NIR) (Foss North America, Eden Prairie, MN). Concentrations of acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), and total digestible nutrients (TDN) were estimated using prediction equations developed by the NIRS Forage and Feed Testing Consortium (Hillsboro, WI). A subset of forage samples were analyzed for NDF and ADF concentrations according to Van Soest et al. (1991) and for concentration of N according to the Kjeldhal procedure (AOAC, 1995), and CP was calculated as N x 6.25. The subset was selected to represent a range of forage maturity by using samples from each paddock and each date that were the highest and lowest canopy heights. Theses values were compared to those predicted by the NIRS Forage and Feed Testing Consortium equations for verification and equation calibration.

Weather Data

Weather instruments operated by AWIS Weather Services, Inc. collected daily minimum and maximum ambient temperatures and daily total precipitation data throughout the experimental period. Weather instruments were located in Headland, AL. Temperature data and total precipitation are reported in Tables 1, 2, and 3, respectively.

Statistical Analysis

All statistical analyses were analyzed using PROC MIXED procedure in SAS 9.4 (SAS Institute, Cary, NC). The experimental unit was paddock in all analyses conducted, treatment was considered a fixed effect, and Yr 1 and Yr 2 data were analyzed separately because of significant differences in climatic conditions between both years. For each year, the statistical model included treatment, sampling date, and treatment × sampling date interaction, as independent variables for forage mass metric and forage nutritive value data. Forage response variables were analyzed as repeated measures over time. The PDIFF option of LSMEANS was used to separate treatment means when protected by F-test at $\alpha = 0.10$.

RESULTS AND DISCUSSION

Temperature and precipitation

Monthly mean temperatures and 30-yr average monthly mean temperatures at the research site from August to January of each year are presented in Table 1. Monthly total precipitation and 30-yr average monthly total precipitation between August and January of each year are presented in Table 2. Mean monthly temperature in Yr 1 was lower in September and November, but was greater in October and December than the 30-yr average. In Yr 2, the mean temperatures in November and December were considerably greater than the 30-yr average. The warmer temperatures experienced during the grazing season led to forage delayed dormancy in Yr 2. In Yr 1, total precipitation in August, October, and December was 18, 35, and 22% greater, respectively, that the 30-yr average. However, total precipitation in September, November, and January was 68, 43, and 56% less, respectively, than the 30-yr average. In Yr 2, total precipitation in August, September, November, and December was 59, 69, 147, and 102% greater, respectively, than the 30-yr average. However, total precipitation in October in Yr 2 was 50% less than the 30-yr average. In Yr 1, the precipitation pattern negatively impacted the quality of the standing forage, beginning in late November through December. In Yr 2, the greater amount of seasonal precipitation, especially in September, November, and December, impacted forage quality. Excessive rainfall and unseasonably warmer temperatures delayed the expected onset of forage dormancy resulting in a higher biomass yield, lower quality forage for grazing in Yr 2.

Table 1. Monthly mean air temperatures (°C) for Yr 1, Yr 2, and 30-yr averages for Headland, AL.

Month	Avg. High, °C	Avg. Low, °C	Mean, °C	30-yr avg., C°
		Year 1		
August	33.8	21.8	27.8	26.8
September	31.5	20.4	22.2	24.4
October	27.4	13.6	20.5	18.8
November	18.6	4.2	11.4	14.1
December	18.7	6.1	12.4	10.1
January	15	2.9	8.9	8.7
		Year 2		
August	33.1	21.9	27.5	26.8
September	29.2	19.2	24.2	24.4
October	25.6	13.9	19.8	18.8
November	22.5	11.5	17	14.1
December	20.9	10.3	15.6	10.1
January	13.9	2.3	8.1	8.7

[+]Data was collected from AWIS Weather Services, Inc.

Table 2. Monthly total precipitation for Yr 1, and Yr 2, and 30-yr averages and differences from 30-yr averages for Headland, AL.

	Total Precipitation, mm+			Differences, mm	
Month	Yr 1	Yr 2	30-yr	Yr 1	Yr 2
August	125.48	168.91	106.43	19.05	62.48
September	34.04	179.07	105.92	-71.88	73.15
October	109.22	40.39	80.77	28.45	-40.38
November	61.21	266.19	107.95	-46.74	158.24
December	130.3	216.66	107.19	23.11	109.47
January	70.36	117.09	160.53	-90.17	-43.44

+Data was collected from AWIS Weather Services, Inc.

Forage Mass, Forage Allowance, Percent Forage Utilization, and Herbage Harvested

Due to the significant differences between both years, data from Yr 1 and Yr 2 were analyzed separately. In both Yr 1 (Table 3) and Yr 2 (Table 4), there were no differences were detected for parameters mean forage mass, forage allowance and percent forage utilization across treatments ($P > 0.10$). However, there were differences in these parameters among sampling dates ($P < 0.10$). In Yr 1, the pre-graze and post-grazing forage mass significantly declined over time. The decline of pre-graze forage mass is expected when grazing stockpiled warm-season grasses, due to forage dormancy (Ball et al., 2015) and the effects of weathering/deterioration. In Yr 2, the pre-graze forage mass did not significantly differ over time ($P = 0.5501$). This pattern is probably attributed to the mild winter experienced in South Alabama in Yr 2, during which temperatures remained elevated compared to the 30-yr average from October through December, which encouraged continued forage growth and lack of dormancy. In Yr 2, post-graze forage mass declined over time. The use of frontal grazing method may be attributed to the declining post-graze mass as steers had continued access to the previously grazed portion of the paddock. This concept also contributes to the significant increase in percent forage utilization over time in both Yr 1 (62 to 94%; $P < 0.0001$) and Yr 2 (84 to 91%; $P = 0.0396$).

Mean pre-graze forage mass across all treatments was 6,147 kg DM/ha and 8,922 kg DM/ha for Yr 1 and Yr 2, respectively. These results are comparable to values from a previous study conducted by McNamee (2014) in which the average pre-graze forage mass of stockpiled Tifton 85 bermudagrass was 6,190 kg DM/ha and 4,207 kg DM/ha for Yr 1 and Yr 2, respectively. These results are also similar to Scarbrough et al. (2001) in which the average forage accumulation ranged from 2,000 to 8,400 kg DM/ha for stockpiled bermudagrass fertilized with 125 kg N/ha, although a lower N application rate was used in the present study.

The relationship between ADG and FA has been described as a linear response up to a FA of approximately 3 kg DM/kg BW (McCartor and Rouquette, 1977) in warm-season forages. Forage allowance significantly declined ($P = 0.0117$) over time during Yr 1 (2.2 to 1.5 kg DM/kg steer BW). However, in Yr 2, forage allowance maintained a similar level across the season, ranging from 3.1 to 3.0 kg DM/kg steer BW ($P = 0.6564$). The FA recorded in Yr 1 may have limited steers ability to achieve a greater ADG. Although the same equation was used to determine the amount of forage to allocate to the steers in both years, forage mass was maintained across the season in Yr 2, resulting in a similar FA across sampling dates, which may contribute to the difference seen in FA between Yr 1 and Yr 2.

The herbage harvested in Yr 1 differed significantly over time ($P = 0.0076$), which increased from early November to late November, and then maintained a similar mass throughout the season. In Yr 1, the first frost of the year occurred on November 15, which may partially explain why the forage mass increased early in the season and was then maintained throughout the season. In Yr 2, the herbage harvested did not significantly differ over time ($P = 0.5801$). The pattern of forage allowance and herbage harvested in Yr 2 is attributed to the mild climatic conditions experienced during the late fall and early winter in Yr 2. In Yr 2, a light frost occurred on November 23 and again on December 19.

Table 3. Date effects of Yr 1 for pre- and post-grazing forage mass, herbage harvested, forage allowance, and percent utilization of stockpiled Tifton 85 bermudagrass.

Sampling Date	Pre-Graze Forage Mass ---------------	Post-Graze Forage Mass kg DM/ha	Herbage Harvested ---------------	Percent Forage Utilization	Forage Allowance kg DM/kg BW
11/6/14	5948[bc]	2227[a]	3721[c]	62[c]	2.2[a]
11/20/14	7421[a]	1490[b]	5931[a]	80[b]	2.0[b]
12/4/14	6654[ab]	763[c]	5891[a]	89[a]	2.0[b]
12/18/14	5501[c]	435[d]	5066[ab]	92[a]	1.6[c]
1/1/15	5212[c]	326[d]	4886[b]	94[a]	1.5[c]
SE	336.21	132.29	394.70	2.81	0.28

[a,b,c,d] Within a column, means differ ($P < 0.10$).

Table 4. Date effects of Yr 2 for pre- and post-grazing forage mass, herbage harvested, forage allowance, and percent utilization of stockpiled Tifton 85 bermudagrass.

Sampling Date	Pre-Graze Forage Mass ---------------	Post-Graze Forage Mass kg DM/ha	Herbage Harvested ---------------	Percent Forage Utilization	Forage Allowance kg DM/kg BW
10/22/15	8797	1381[a]	7416	84[b]	3.1
11/5/15	9156	1020[b]	8136	88[a]	3.1
11/19/15	9377	1072[b]	8305	88[a]	3.2
12/3/15	8879	798[c]	8134	91[a]	3.0
12/17/15	8403	.	.	.	.
SE	403.54	87.11	495.04	1.34	0.47

[a,b,c] Within a column, means differ ($P < 0.10$).

Forage chemical composition and nutritive value of stockpiled Tifton 85 bermudagrass

For stockpiled Tifton 85, there were no significant differences in forage quality parameters crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and total digestible nutrients (TDN) among treatments ($P > 0.10$) in either year. However, there were differences across sampling dates ($P < 0.0001$) such that pre-graze forage quality in Yr 1 and Yr 2 (Table 5 and Table 6, respectively) generally declined as the grazing season progressed. Plant maturity has been cited as the primary factor influencing forage quality (Buxton and Fales, 1994), and changes in quality in the present study maybe attributed to deteriorating plant DM over time.

Mean forage CP concentration significantly declined over the grazing season in both years ($P < 0.0001$). These values are less than those reported by McNamee (2014) who observed a decline in CP concentration from 18.4 to 10.4% across the grazed stockpiled Tifton 85 season; however, the pastures in their study were fertilized with greater rates of N (56 to 168 kg N/acre). Hill et al. (1993) reported Tifton 85 mean CP concentration increased from May to September (11.4 to 15.6%, respectively) during active growth as determined by forage masticate samples taken over the 3-yr trial. Mandebvu et al. (1999) compared Tifton 85 and Coastal bermudagrass by harvesting them at different stages of growth beginning with 2 wks after July 7 and determined the mean CP concentration of 20.8%. After 7 wks of growth, a mean CP concentration of Tifton 85 declined to 11.1%, illustrating a decline from initial CP concentration with increasing length of regrowth period. Highly soluble N in cured standing forage may be more susceptible to leaching during extended periods of grazing deferral and (or) with high levels of precipitation (Lalman et al., 2000), which may lead to the lower CP concentrations experienced in the present study.

Evers et al. (2004) evaluated the influence of month and cultivar on crude protein concentration in warm-season perennial grasses as standing hay from October to February at Overton, TX and observed Tifton 85 to have a mean CP concentration of 12.5%. This value is slightly higher than the CP concentrations from the present study. However, Evers et al. (2004) observed the same pattern as in the present study with respect to the CP concentration slow decline from October to February.

Total cell-wall constituents are key determinants of forage DMI and digestibility. Forage concentration of NDF, which consists of hemicellulose, cellulose, and lignin is inversely related to voluntary DMI in ruminants. Forage concentration of ADF, which consists of cellulose and lignin, is inversely related to forage DM digestibility (Van Soest, 1994). The NDF and ADF concentration in both Yr 1 and Yr 2 significantly increased over the grazing season. Mean forage NDF concentrations ranged from 70 to 77% in Yr 1 and 72 to 75% in Yr 2. These values are slightly greater than the mean forage NDF concentration reported by McNamee (2014) for both Yr 1 (69.3%) and Yr 2 (66.4%) with stockpiled Tifton 85 bermudagrass. Scaglia and Boland (2014) compared bermudagrass hybrids for effects of sampling day (0 to112 d) on forage characteristics and nutritive value and reported that actively growing Tifton 85 had a mean NDF concentration of 71.5%, which was significantly greater than that of Alicia and comparable to the NDF concentrations seen in the present study. Mean ADF concentrations for Yr 1 and Yr 2 ranged from 35.6 to 41.4% and 37.8 to 39.7%, respectively, which are slightly greater than the mean ADF concentrations reported by McNamee (2014) for both Yr 1 (32.7%) and Yr 2 (29.8%) of the stockpiled Tifton 85 bermudagrass. The increase in fiber content of the stockpiled forage is expected as the grazing season extends, due to weathering and leaf loss. The weathering of the forage contributes to the higher ratio of stem to leaf and the leaf contains a higher nutritive value compared with the stem portion of the forage. The forage fiber increases due to the cell walls becoming more lignified. Throughout the grazing season, the stockpiled forage complete its actively growing life stage and goes into dormancy, no longer maintaining food reserves.

Average TDN concentration also declined across sampling dates in Yr 1 and Yr 2 ($P <$ 0.0001 and $P = 0.0003$, respectively). The decline of CP and TDN concentrations agree with Jennings et al. (2009) who observed that CP and TDN of stockpiled bermudagrass declined as weathering increased from October to February (81% to 48.8% TDN, respectively) in Arkansas. The declining forage nutritional value in Yr 1 is partially attributed to increasing rainfall beginning in late November into December along with decreasing temperature. In Yr 2, the exceptionally greater amount of precipitation when compared with the 30-yr average, especially in November and December, led to a decline of forage nutritive quality through weathering and deterioration in the early winter months. Periods of extensive rainfall destroy the nutritious leafy material of the forage, leaving only the stem, which is thick, unpalatable, and has less nutritional value for the grazing ruminant. As the proportion of stem increases as part of the total forage mass, structural carbohydrate content (ADF and NDF) increases, which may reduce forage digestibility and intake (Nelson and Moser, 1994). The overall average temperatures in Yr 2 were more conducive for slow, continued growth in grazed stockpiled warm-season forage compared with Yr 1 due to the mild warm winter experienced. The mild winter experienced in South Alabama in Yr 2, encouraged extremely slow growth during this period when it would have normally been dormant.

Table 5. Chemical composition of Tifton 85 bermudagrass samples collected during the 2014 grazing season. All data are presented as percent of DM.

Sampling Date	Crude Protein	Acid Detergent Fiber	Neutral Detergent Fiber	Total Digestible Nutrients
	---------------	% DM basis		---------------
11/6/14	9.1[a]	35.6[c]	70.1[b]	62.0[a]
11/20/14	8.1[b]	37.4[b]	70.5[b]	55.9[b]
12/4/14	6.5[d]	41.1[a]	76.8[a]	55.7[c]
12/18/14	6.8[d]	41.4[a]	77.5[a]	55.4[c]
1/1/15	7.1[c]	41.4[a]	77.2[a]	55.3[c]
SE	0.23	0.37	0.40	0.42

[a,b,c,d] Within a column, means differ ($P < 0.10$).

Table 6. Chemical composition of Tifton 85 bermudagrass samples collected during the 2015 grazing season. All data are presented as percent of DM.

Sampling Date	Crude Protein	Acid Detergent Fiber	Neutral Detergent Fiber	Total Digestible Nutrients
	---------------	% DM basis		---------------
10/22/15	11.7[a]	37.8[b]	72.2[c]	59.4[a]
11/5/15	9[b]	39.8[a]	73.5[b]	57.2[b]
11/19/15	7.8[c]	40.1[a]	74.2[a]	56.9[b]
12/3/15	6.6[d]	39.7[a]	75.0[a]	57.3[b]
12/17/15	6.7[d]	39.7[a]	74.6[a]	57.3[b]
SE	0.29	0.27	0.50	0.31

[a,b,c,d] Within a column, means differ ($P < 0.10$).

Forage chemical composition and nutritive value of the Tifton 85 bermudagrass hay

For the Tifton 85 hay in Yr 1 (Table 7) and Yr 2 (Table 8), there were no significant differences were detected in forage quality parameters crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), or total digestible nutrients (TDN) concentration across treatments ($P > 0.10$). Across all sampling dates for Yr 1, the mean CP did not differ (P = 0.3425); however, in Yr 2, the CP concentration significantly declined from 6.2 to 5.5% (P = 0.0666). The mean CP concentration across all sampling dates was 10.4 and 6.2% in Yr 1 and Yr 2, respectively. Scaglia and Boland (2014) compared bermudagrass hybrids on number of round bales produced per hectare and nutritive value, and reported Tifton 85 had the lowest mean CP concentration of 11.0% compared with Alicia and Jiggs when harvested in July, August, and September of each year.

The ADF concentration in both years did not differ significantly across sampling dates (P = 0.9724 and P = 0.4385, Yr 1 and Yr 2, respectively). The NDF concentration in Yr 1 declined from 73.3 to 70.6%, but in Yr 2 the NDF concentration did not significantly differ across sampling dates (P = 0.2730). Burns and Fisher (2007) reported a mean NDF concentration of 67.7% for Tifton 85 bermudagrass hay in the central Piedmont of North Carolina, which is comparable to values observed in the present study. Mandebvu et al. (1999) compared Tifton 85 hay with Coastal bermudagrass hay harvested after 3, 5, and 7 wks of regrowth (vegetative stage of growth, nonflowering stems) and reported that Tifton 85 hay had greater mean concentrations of NDF (75.1%) and ADF (32.8%), which are similar to both Yr 1 and Yr 2 mean NDF (72.2 and 78.6%, respectively) and ADF (38.6 and 41.1%, respectively) concentrations reported in the current evaluation. Tifton 85 had greater cell-wall concentration, but had lower acid insoluble lignin. Mandebvu et al. (1999) concluded that the ferulic acid linkages between lignin and cell wall polysaccharides contribute to the ability to be digested. Tifton 85 had greater concentrations of total ester ferulic acid and lower concentrations of ether ferulic acid when compared with Coastal bermudagrass. Ruminal bacteria possess phenolic acid esterases that break down the ferulate ester linkages, while they are not known to have the ability to break down ether linkages.

In both years, hay TDN concentration did not differ across sampling dates ($P = 0.9721$ and $P = 0.4373$, in Yr 1 and Yr 2, respectively). The mean TDN concentrations for both Yr 1 (58.6%) and Yr 2 (55.7%) did not meet the nutrient requirements for a 280-kg growing steer, which is 63% TDN (NRC, 2000), when fed alone. Lesser quality of Tifton 85 bermudagrass hay may be attributed to differences in harvest frequency among cuttings due to rainfall distribution during the summer months.

Table 7. Chemical composition of Tifton 85 bermudagrass hay samples collected during Yr 1 of study. All data are presented as percent of DM.

Sampling Date	Crude Protein	Acid Detergent Fiber	Neutral Detergent Fiber	Total Digestible Nutrients
	---------------	% DM basis		---------------
11/6/14	9.9	38.8	73.3[a]	58.4
12/4/14	10.2	38.5	72.7[ab]	58.6
1/16/15	11.3	38.5	70.6[b]	58.7
SE	0.67	0.89	0.86	1.01

[a,b] Within a column, means differ ($P < 0.10$).

Table 8. Chemical composition of Tifton 85 bermudagrass hay samples collected during Yr 2 of study. All data are presented as percent of DM.

Sampling Date	Crude Protein	Acid Detergent Fiber	Neutral Detergent Fiber	Total Digestible Nutrients
	---------------	% DM basis		---------------
10/28/15	6.2[ab]	41.5	78.2	55.3
11/23/15	6.7[a]	40.8	78.5	56.1
12/18/15	5.5[b]	41.0	79.0	55.9
SE	0.33	0.40	0.33	0.46

[a,b] Within a column, means differ ($P < 0.10$).

Steer initial, final, and ADG from stockpiled Tifton 85 and Tifton 85 hay treatments

Animal response variables for the stockpiled T85 bermudagrass and T85 hay treatments are presented in Tables 9 and 10 for Yr 1 and Yr 2, respectively. Mean Initial BW in Yr 1 did not differ across all treatments (*P* = 0.3785); however, in Yr 2, mean initial BW did significantly differ across treatments (*P* = 0.0013) due to greater variation in the steer weights in the group in Yr 2. Across all treatments in Yr 1, there were no significant differences in mean final animal BW (*P* = 0.5247). However, in Yr 2, there was a significant difference in mean final BW (*P* = 0.0790) across treatments. There were no significant differences among hay treatments with or without supplementation in Yr 2. However, the stockpiled T85 treatments had lower final BW compared with the T85 hay only treatment. No significant differences were observed in final BW among stockpiled T85 or T85 hay treatments with additional supplementation. There were no treatment effects for ADG in Yr 1, but differences were observed in Yr 2. In Yr 1, all but one treatment (Hay + 50/50) experienced a negative mean ADG. These negative ADG did not meet the satisfactory target of a positive gain. Forage availability and the nutritional value of the available forage both contribute to the performance of the animals as well. In Yr 1, the supplemented treatments allowed the steers to achieve maintenance energy requirements because they were supplemented with additional nutrients to make up for the forage deficit in TDN and CP. These results suggest that a higher level of supplementation would be needed to achieve desired daily gain. In Yr 2, ADG of steers grazing stockpiled T85 treatments with supplementation (T85 + 25/75 and T85 + 50/50) were not different. The mean ADG for the T85 hay plus supplement treatments also did not differ. When fed stockpiled T85 or T85 hay alone, ADG was not different among treatments; however, these had a lower ADG compared to those containing supplementation. In Yr 2, the control and the supplemented treatments all achieved a positive gain; however, the gain achieved slightly above maintenance.

Scaglia and Boland (2014) compared ADG from beef steers grazing different bermudagrass hybrids during a 112-d grazing period and reported that steers grazing Tifton 85 had a greater ADG (0.55 kg/d) compared with Jiggs (0.51 kg/d) and Alicia (0.36 kg/d). Hill et al. (1993) reported Tifton 85 produced a mean steer ADG of 0.67 kg/d whereas Tifton 78 produced a mean ADG of 0.65 kg/d from a 3-yr grazing trial during active forage growth. Lower gains in the present study were likely attributed to quality differences in stockpiled Tifton 85 compared with actively growing forage reported by Scaglia and Boland (2014) and Hill et al. (1993).

Galloway et al. (1993a) reported when steers grazing bermudagrass were supplemented with grain (0.67% BW of ground corn, 0.67% of BW whole corn, 0.73% of BW ground sorghum grain or 0.67% of BW ground wheat), there was a general increase in the ADG compared with steers grazing bermudagrass alone, which was observed the present study although the magnitude of the response was small. The authors concluded that ADG of steers grazing bermudagrass pasture during summer is increased with supplements containing low-protein concentration and fed at low levels (≤ 0.5% of BW). Aiken (2002) conducted a study evaluating rates of supplementation with ground corn (0, 0.45, 1.35 and 2.25 kg steer^{-1}d^{-1}) on bermudagrass pastures by growing steers and reported that there was a strong curvilinear increase in ADG with increased levels of corn supplementation. The lower levels of supplementation used by Aiken (2002) are comparable to the levels supplemented in the present study (0 and 0.9 kg/hd/d). The authors noted that the ADG consistently increased between the 0 and 1.35 kg corn/steer $^{-1}$d^{-1} rates, and stabilized between the 1.35 and 2.25 kg rates. Results from the present study do not show this curvilinear increase when the treatments with the greater ratio of energy are supplemented. There was no difference in either Yr 1 or Yr 2 for supplementation treatments.

Wheeler et al. (2002) conducted a 2-yr experiment to determine diet nutritive value from stockpiled bermudagrass pasture from November through February in Stillwater, Oklahoma. Four esophageal fistulated heifers were used to collect masticate samples and the masticate DIP (% of CP) ranged from 50 to 69% of the total CP over both years. Wheeler et al. (2002) also evaluated the effects of supplementation on the performance of cows grazing stockpiled bermudagrass pastures. Treatments were as follows: no supplement (control), or daily equivalents of 0.2 (low), 0.4 (medium), and 0.6 (high) g of supplemental protein per kg of BW. Supplements were varying concentrations of soybean hulls and soybean meal to create incremental increases in supplemental DIP and CP. Results indicate that the low supplement (13% CP) provided sufficient protein to meet the needs of gestating beef cows grazing stockpiled bermudagrass forage during winter containing moderate levels of DIP. In the present study, supplements were designed to provide complementary sources of undegradable intake protein and energy to growing steers. Total CP concentrations of the forage used were less than the NRC (2000) requirement for supporting gain, and supplementation responses in this evaluation were likely due to a deficit of total CP rather than specific DIP/UIP ratios.

To achieve the desired gain of a stocker producer (0.90 kg/day), supplementation level would need to be increased, but still focused on the specificity of RUP and energy in the case of stockpiled forage. Using stockpiled Tifton 85 bermudagrass to achieve a level of maintenance is acceptable for cow/calf operations as shown by McNamee et al. (2014), but in the stocker cattle industry, weight gain is desired.

Table 9. Average daily gain, initial, and final body weight of steers grazing stockpiled Tifton 85 bermudagrass or fed Tifton 85 bermudagrass hay with or without supplementation for Yr 1.

	Treatment							
Item	T85	T85 + 50/50	T85 + 25/75	Hay	Hay + 50/50	Hay + 25/75	Mean	SE
Initial BW, kg	286	279	282	280	277	279	281	2.58
Final BW, kg	258	279	276	270	292	272	278	11.52
ADG, kg	−0.49	−0.02	−0.11	−0.17	0.26	−0.13	-0.11	0.17

^{a,b} Within a row, means differ ($P < 0.10$).

Table 10. Average daily gain, initial, and final body weight of steers grazing stockpiled Tifton 85 bermudagrass or fed Tifton 85 bermudagrass hay with or without supplementation for Yr 2.

	Treatment							
Item	T85	T85 + 50/50	T85 + 25/75	Hay	Hay + 50/50	Hay + 25/75	Mean	SE
Initial BW, kg	236^{d}	245^{c}	242^{c}	261^{a}	250^{b}	255^{b}	249	2.08
Final BW, kg	244^{c}	262^{b}	260^{b}	272^{a}	263^{ab}	270^{ab}	262	4.01
ADG, kg	0.21^{c}	0.32^{a}	0.32^{a}	0.18^{c}	0.24^{b}	0.29^{ab}	0.26	0.04

^{a,b,c,d} Within a row, means differ ($P < 0.10$).

Conclusions

Results from the warm-season portion of this study suggest that stockpiled Tifton 85 bermudagrass along with supplemental CP and energy can support stocker cattle performance at a level of maintenance, but to achieve the desired gain of 0.9 kg/day, there must be a greater level of supplementation provided. Stockpiled forage quality tends to decline as the grazing season progresses. The greater level of supplementation would still have to be properly balanced for RUP and energy. With a proper supplementation strategy, the declining forage nutritive value of the stockpiled forage can be overcome. There were no significant differences in animal performance of the stockpiled Tifton 85 bermudagrass treatments compared with the hay treatments, meaning that stockpiled Tifton 85 bermudagrass can be used to replace the use of hay to fill the fall-forage gap experienced in the Southeast. This information is especially useful to beef producers in Alabama and the Lower Coastal Plain region, who may be interested in extending their fall grazing season and replacing the use of hay to cover this forage gap. Further research is needed to determine the level of supplementation needed when grazing stockpiled Tifton 85 bermudagrass to overcome the declining nutritional value during the early winter months to achieve the stocker producer's desired level of gain.

III. BEEF STOCKER STEERS PERFORMANCE, FORAGE PRODUCTIVITY AND QUALITY FROM MIXED RYE/RYEGRASS PASTURES

INTRODUCTION

Hoveland et al. (1986) suggested that the greatest opportunity for profitability in the Southeastern beef industry is with stocker beef cattle grazing high-quality cool-season annual forages such as small grains and ryegrass. Winter annuals (i.e., small grains and annual ryegrass) provide high-quality forage for livestock and have a long production season (Ball et al., 2015). In the southeastern U.S., using a small-grain/ryegrass mixture for a cover crop is common practice (Oelke et al., 1990). During the winter and spring when row crop fields lay dormant and unused, cover crops can be planted to provide grazing and protect the soil. Grazing a winter cover crop provides a whole-systems approach type of management, which may be potentially profitable for the producer. However, distribution of forage growth differs greatly among cool-season forage species, which is extremely important to consider when planning an integrated row crop and grazing system. An opportunity exists for using mixtures of annual ryegrass and small grains that differ in their individual growth pattern to more evenly distribute and guarantee availability of high-quality forage through the winter grazing season (Mullenix et al., 2012). Buckner and Raymer (1990) concluded that rye is better suited for grazed cover crops systems than other small grains due to its cold tolerance and forage production potential, especially during the winter months. Oat is a small grain that is often grown across the U.S., but has greater productivity in the lower South (Ball et al., 2015). Annual ryegrass is considered to be one of the highest quality winter forages utilized in the southeastern U.S. and has become an important component in winter forage-livestock systems (Blount and Prine, 2012). There are many different varieties of ryegrass that differ in their ploidy level (diploid or tetraploid) and maturity (early- or late-maturing types). ‘Earlyploid’ is a tetraploid ryegrass variety that stands out for potential use in stocker-row crop systems. This variety is an earlier forage-producing tetraploid ryegrass that is commercially available and exhibits comparable seasonal yield to other ryegrass varieties with improved disease resistance (Blount et al., 2013). ‘Marshall’ ryegrass is a commonly used diploid annual ryegrass in the Southeast (Blount and Prine, 2012) with mid- to late-maturity and good forage production potential. In a systems management approach, the entire system has to be considered, including both the animal and crop components. The row crop to follow the grazed cover crop has to be planted during a certain window, so the grazed cover crop has to exhaust its life cycle before the following crop is to be planted. Choosing combinations of cover crops to graze that will be beneficial for both animal and crop production is important and necessary to be economical. Research is needed to identify combinations of these forages to support a winter and spring grazing system for stocker producers as grazed cover crops to use prior to fields being utilized for row crops.

MATERIALS AND METHODS

Experimental Site

All procedures and experimental protocols were approved by the Auburn University Institutional Animal Care and Use Committee (IACUC Protocol No. 2014-2519).

The cool-season grazing experiment was conducted at the Wiregrass Research and Extension Center (WREC) in Headland, AL (31.35°N lat., 85.34°W long.). Twelve 1.21-ha paddocks composed of Dothan fine sandy loam (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults) were used for this experiment in Yr 1, and nine were used in Yr 2. Yr 1 pastures had been planted in pearl millet (*Pennisetum glaucum L.*) during the summer prior to cover crop establishment. In Yr 2, pastures were previously planted with annual peanut (*Arachis hypogaea L.*).

Experimental Design

A 2-yr grazing evaluation was conducted in the winter of 2015 (Yr 1) and 2016 (Yr 2). Twelve 1.21-ha paddocks with four replications of three treatments in Yr 1 and three replications of three treatments in Yr 2. Fewer replicates were included in Yr 2 due to seed supply shortage. Treatments included combinations of: Florida 401 rye and Earlyploid annual ryegrass (R-E), Florida 401 rye and Marshall annual ryegrass (R-M), and Florida 401 rye and RAM Oats (R-O). Treatments were arranged in a completely randomized design.

Pasture Management

Land preparation for cool-season pastures began following annual crop harvest in October of each year. Two 8.4-ha fields were divided into 1.21-ha paddocks and used for establishment of cool-season annual cover crops. All pastures were planted with a no-till drill using a rye-ryegrass (seeding rate of 100 kg/ha and 16 kg/ha, respectively) or rye-oats mixture (seeding rate of 56 kg/ha and 56 kg/ha, respectively) in November of each year. In Yr 1, the experimental area received 34 kg N/ha, 45 kg P/ha, 45 kg K/ha, and 12 kg S/ha on October 14 and a second application with these rates on November 5. On November 21, planting of the rye-ryegrass and rye-oats began and ended on December 1. These paddocks received 79 kg N/ha and 12 kg S/ha on December 9. In Yr 2, the experimental area received 34 kg N/ha, 68 kg P/ha, and 34 kg K/ha on October 15. Planting of the rye-ryegrass and rye-oats began on November 16 and ended on November 17. On December 11, these paddocks received 79 kg N/ha and 14 kg S/ha. Applications of P and K at planting were according to soil test recommendations of Auburn University Soil Testing Laboratory.

Animal Management

Steers used for the warm-season study were also used for the cool-season grazing evaluation. Steers from the warm-season study were re-randomized based on initial body weight and placed on one of the three treatments, with a maximum of five steers per paddock. In between studies (two to three week time period), steers were given free-choice access to remaining stockpiled bermudagrass and fed supplement (50/50 soybean hulls and corn gluten feed at 0.25% of BW per day).

Following the initiation of the cool-season evaluation, steers were provided a free-choice high magnesium (10%) mineral mix (Special Mag, W.B. Fleming Company, Tifton, GA) and water *ad libitum* throughout the study. Pastures were managed using continuous stocking in both years of the study, and animals were fasted prior to collecting weights during the study.

Animal Responses

During both years of study, test steers were weighed initially and then randomly assigned to their respective treatment group. In Yr 1, each treatment group received five steers. In Yr 1, steers (initial BW 279 ± 49 kg) were randomly assigned to treatments on February 5 and removed on April 3 (57 grazing days) when forage mass fell below 500 kg DM/ha. In Yr 2, steers (initial BW 281 ± 17 kg) were randomly assigned to R-E and R-M treatments on February 1 and February 11 for the R-O after forage had achieved the target grazing height (20 to 30 cm). In Yr 2, R-E, R-M, and one of R-O (paddock 2) received five steers, and the other two R-O treatments group received three steers due to low forage availability and stand density in these treatments. Steers were removed from treatments on March 9, March 17, March 21, or March 24 when forage availability fell below 500 kg DM/ha. In Yr 2, the steers on the R-E, R-O, and R-M treatments had an average of 37, 42, and 44 grazing days, respectively. Steer weights were taken at 28-d intervals during the experimental period. Initial and final BW, ADG were calculated and are reported in the results and discussion. Average daily gain was calculated per animal by subtracting the initial weight before grazing final weight once removed from the grazing experiment, divided by the total number of days on test. These values were averaged per paddock for analysis by treatment.

Pasture Responses

Prior to the experiment and every 2 wk thereafter, direct forage samples were clipped from three locations representative of the range of available forage DM within each paddock in order to determine forage mass and nutritive value. Along with these three direct samples, available forage DM was estimated utilizing a calibrated falling disc meter as an indirect measure as described in Bransby et al. (1977). In this study, available forage DM is defined as the plant material that is greater than 5 cm from the soil surface. Thirty disk meter readings were randomly taken from each paddock. The three collected samples were clipped, placed in cloth bags, and then transported back to Auburn University Forage Quality Laboratory. Samples were dried to a constant weight in a forced air oven at 60°C and weighed. The recorded forage mass values were plotted against their respective height values, and the resulting regression equation was used to calculate approximate forage mass for each test pasture. A new regression equation was produced following each sampling date to account for changing variability in plant maturity over time. The mean forage height from each test pasture was multiplied by the slope of the regression line and added to the y-intercept value to yield the estimated mean forage mass in each test pasture. Forage allowance (FA) was determined by the following equation: (kg forage DM/ kg animal body weight per paddock) as reported by Sollenberger et al. (2005). Forage samples were ground to pass through a 1-mm screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ).

All forage samples were scanned using a Perstorp Analytical 5000 near infrared spectrophotometer (NIR) (Foss North America, Eden Prairie, MN). Acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), and total digestible nutrients (TDN) concentrations were estimated using prediction equations developed by the NIRS Forage and Feed Testing Consortium (Hillsboro, WI). A subset of forage samples were analyzed for NDF and ADF according to Van Soest et al. (1991), and concentration of N determined according to the Kjeldhal procedure (AOAC, 1995); CP was calculated as N x 6.25. A subset was determined to achieve a range by using the samples that were the highest and lowest heights to represent a range of forage maturity from each paddock and each date. These values were compared to those predicted by the NIRS Forage and Feed Testing Consortium equations for verification.

Weather Data

Weather instruments operated by AWIS Weather Services, Inc. collected daily minimum and maximum ambient temperatures and daily total precipitation data throughout the experimental period in Headland, AL. Temperature and total precipitation data are reported in Tables 12, 13, and 14, respectively.

Statistical Analysis

All statistical analysis were conducted using the PROC MIXED procedure in SAS 9.4 (SAS Institute, Cary, NC). Treatments are arranged in a completely randomized design (pasture = experimental unit; 12 experimental units; 4 replications/treatment) in Yr 1 and (pasture = experimental unit; 9 experimental units; 3 replications/treatment) in Yr 2. Year, forage treatments, and their interaction were considered fixed effects. Test steer data was used to calculate initial BW, final BW, and ADG. Forage metrics and nutritive value parameters quantified throughout the growing season were treated as repeated measures. The PDIFF option of LSMEANS was used to separate treatment means when protected by F-test at $\alpha = 0.10$.

RESULTS AND DISCUSSION

Temperature and precipitation

Monthly mean temperatures and 30-yr average monthly mean and monthly total precipitation and 30-yr average monthly total at the research site from January to April of each year are presented in Tables 11 and 12, respectively. Mean monthly temperature in Yr 1 was lower in November and February, but was greater in December, March, and April than the 30-yr average. In Yr 2, the mean temperature in January was lower, but was greater in November, December, February, and March than the 30-yr average. In Yr 1, total precipitation in November, January, February, and March was 43, 56, 31, and 73% less, respectively, than the 30-yr average. However, total precipitation in December and April was 22 and 18% greater than the 30-yr average in Yr 1. In Yr 2, total precipitation in January and March was 27 and 32% less, respectively, than the 30-yr average. Total precipitation in November, December, and February was 147, 102, and 10% greater than the 30-yr average in Yr 2. The temperature differences did not greatly affect the forage quality nor the grazing season duration in either year. However, greater rainfall during early growth in Yr 2 impacted forage stand density, resulting in less ground cover in small-grain/ryegrass mixtures.

Table 11. Monthly mean air temperatures (°C) for Yr 1, Yr 2, and 30-yr averages for Headland, AL.

Month	Avg. High, °C	Avg. Low, °C	Mean, °C	30-yr avg., C°
		Year 1		
November	18.6	4.2	11.4	14.1
December	18.7	6.1	12.4	10.1
January	15	2.9	8.9	8.7
February	14.1	1.1	7.6	10.8
March	22.5	11.1	16.8	14.8
April	26.2	15.9	21.1	18.5
		Year 2		
November	22.5	11.5	17	14.1
December	20.9	10.3	15.6	10.1
January	13.9	2.3	8.1	8.7
February	17.7	4.7	11.2	10.8
March	22.7	11.0	16.9	14.8

+Data was collected from AWIS Weather Services, Inc.

Table 12. Monthly total precipitation for Yr 1, and Yr 2, and 30-yr averages and differences from 30-yr averages for Headland, AL.

	Total Precipitation, mm[+]			Differences, mm	
Month	Yr 1	Yr 2	30-yr	Yr 1	Yr 2
November	61.21	266.19	107.95	-46.74	158.24
December	130.3	216.66	107.19	23.11	109.47
January	70.36	117.09	160.53	-90.17	-43.44
February	90.93	145.54	131.83	-40.9	13.71
March	43.18	106.17	156.97	-113.79	-50.8
April	113.54	110.24	96.52	17.02	13.72

[+]Data was collected from AWIS Weather Services, Inc.

Forage Mass and Forage Allowance

Data from Yr 1 and Yr 2 were analyzed separately due to the significant differences between years. Mean forage mass and FA did not differ among treatments ($P > 0.10$) in either year. However, there were differences in mean forage mass and FA across sampling dates in both Yr 1 (Table 13) and Yr 2 (Table 14). In both years, mean forage mass and forage allowance were greatest early in the grazing season (largely February), but then declined over time. Observational differences in seasonal growth distribution of the small grains were evident during this period, with slightly increasing productivity of oats observed following that of rye (Ball et al., 2015), which may explain the noticeable increase in forage mass and allowance early in the season in Yr 1. Average forage mass across treatments was less in Yr 2 than Yr 1, affecting the total number of grazing days in Yr 2. During the planting of forage mixtures in Yr 2, the day after planting (November 17) was followed by a heavy rain, which may have impacted stand density. The R-O treatments (in paddocks 8 and 12) suffered the most, and ground cover estimates for percentage of oats and rye, weeds, and bare ground were taken on February 11. Mean ground cover estimates for paddock 8 were 27, 63, and 14.5% and for paddock 12 were 36.5, 29, and 27.3% for percentage of oats and rye, weeds, and bare ground, respectively. Forage mass maintained a similar level of production during the early portion of the grazing season in Yr 2, which is likely a result of forage being maintained in more of a vegetative state under conditions of lower forage production. Results from Yr 1 of the present study contrast those observed by Vendramini et al. (2006) where rye + ryegrass pastures produced an average herbage mass of 2,100 kg DM/ha and declined to 1,600 kg DM/ha from February to April in a 2-yr grazing trial; however, forage production responses were similar in Yr 2. Differences in results seen from Vendramini et al. (2006) and the present study may be partially attributed to differences in grazing management. In the present study continuous grazing was used, whereas Vendramini et al. (2006) used rotational grazing methods. Rotational stocking management may have enabled forage to be managed more intensively, resulting in similar to declining forage mass across the production season. Redfearn et al. (2005) noted that the greatest forage production of ryegrass often occurs from March onward, although yield is dependent on variety selection. It is important to note that there was no treatment × date interaction for forage mass, indicating a similar growth distribution among forage species mixtures in the present study.

Results for FA in Yr 1 and Yr 2 do not reveal significant differences among treatments, which is expected because this is determined from forage mass. However, there were differences in FA by date and a pattern of increase and then decrease as the season progresses was observed. This pattern is probably attributed to the bump in forage mass from the early production of the mixtures. Beck et al. (2013) developed a nonlinear regression model, which predicts that a FA of 1.8 is needed to maintain ADG of 0.9 kg for cool-season forage systems. Results from Yr 1 across all treatments are in contrast with model determined by Beck et al. (2013). The mean FA achieved across the grazing season was between 1.0 to 4.1 kg DM/kg BW and produced an ADG of 0.50 to 0.66 kg/d. However in Yr 2, the achieved FA does support this model. In Yr 2, the mean FA achieved across the grazing season was between 0.6 to 2.4 and produced an ADG of 1.41 to 1.56 kg/d. These results were comparable to FA values reported by Mullenix et al. (2014). Mullenix et al. (2014) produced an ADG of 1.2 kg/d from ryegrass and small-grain pastures with a FA of 1.36 kg DM/kg BW using a put-and-take grazing method. Similarly, Marchant (2014) produced a mean ADG of 1.44 kg/d with a FA of 0.89 kg DM/kg BW using a put-and-take grazing method. It is important to note that different grazing management strategies were used in previously mentioned studies rather than continuous stocking like used in the present study. Continuous stocking using a fixed stocking rate differs from the put-and-take grazing method. Put-and-take controls grazing pressure in evaluating animal performance and stocking rate response to treatments, whereas a fixed stocking rate controls the stocking rate to evaluate animal performance and grazing pressure responses on treatments (Aiken, 2016). Put-and-take is managed to keep the forage in a vegetative state to support a greater gain for the animals grazing, but continuous, fixed stocking rate systems allows animals to be more selective. Due to continuous stocking using a fixed stocking rate, the forage in Yr 1 outgrew the ability of animals to graze and manage it in a vegetative state, whereas in Yr 2, less forage availability allowed the forage to be better maintained in a vegetative stage of growth.

Table 13. Date effects of Yr 1 for forage mass and forage allowance for grazed cool-season annuals.

Sampling Date	Forage Mass (kg DM/ha)	Forage Allowance (kg DM/kg BW)
1/30/15	1731[c]	1.5[c]
2/13/15	4818[a]	4.1[a]
2/27/15	4866[a]	4.1[a]
3/13/15	3351[b]	2.7[b]
3/27/15	1451[c]	1.2[c]
4/6/15	1385[c]	1.0[c]
SE	435.96	0.36

[a,b,c] Within a column, means differ ($P < 0.10$).

Table 14. Date effects of Yr 2 for forage mass and forage allowance for grazed cool-season annuals.

Sampling Date	Forage Mass (kg DM/ha)	Forage Allowance (kg DM/kg BW)
1/25/16	2287[a]	1.9[a]
2/4/16	2529[a]	2.2[a]
2/18/16	2782[a]	2.4[a]
3/3/16	1624[b]	1.2[b]
3/21/16	814[c]	0.6[c]
SE	276.12	0.23

[a,b,c] Within a column, means differ ($P < 0.10$).

Forage chemical composition and nutritive value of the cool-season annual mixtures

For Yr 1 (Table 15), there were no differences in CP, ADF, NDF, and TDN concentrations among treatments ($P > 0.10$). However, in Yr 2 (Table 16), there were significant differences among treatments in CP ($P = 0.0114$), ADF ($P < 0.0001$), NDF ($P < 0.0001$), and TDN ($P < 0.0001$). In Yr 2, the R-E and R-O treatments had greater mean CP concentrations than the R-M treatments. The R-M treatments had greater mean ADF and NDF concentrations than the R-O and R-E treatments. Mixtures of R-O and R-E had greater mean TDN concentrations that the R-M treatments, which can be partially attributed to less cell-wall constituents associated with these mixtures. These results suggest that R-O and R-E had greater nutritive quality than R-M in Yr 2, although all forage treatments maintained a high level of nutritive value throughout the study.

As expected, the forage nutritive value across treatments generally declined as the grazing season progressed in both years (Tables 17 and 18, respectively). Across all treatments, mean forage CP declined over the grazing season ($P < 0.0001$ for both Yr 1 and Yr 2, respectively). In Yr 1, mean forage CP concentration decreased from approximately 26 to 17% across the entire season. Redfearn et al. (2002) observed a similar pattern for CP concentration in ryegrass from December to May (26 to 12%) in Oklahoma. A decline in CP concentration is also reported by Ball et al. (2015) in respect to rye from 28, 24, and 13% at the vegetative, flower/boot and fruit/head stages of maturity, respectively. Ball et al. (2015) also stated that CP concentration of ryegrass declines from 12 to 16% in the vegetative-boot stage to 8 to 12% in the boot-head stage. Results from Yr 1 and Yr 2 for mean CP concentration in the R-M treatments are comparable with Hafley (1996). Hafley (1996) conducted a 2-yr study continuously grazing ‘Marshall’ ryegrass and observed a wide range of CP concentrations (10.7 to 26.1%). These studies illustrate decreasing CP concentration with increasing plant maturity during the grazing season.

Mean ADF and NDF concentrations in both years increased over the grazing season ($P < 0.0001$ for both Yr 1 and Yr 2, respectively). These results are comparable to Beck et al. (2007) who reported that NDF concentrations across the season ranged from 40 to 52% for mixtures of small grains and ryegrass in Arkansas. Hafley (1996) reported NDF concentrations for 'Marshall' ryegrass ranging from 40.5 to 57.1% over three 28-d harvests, which are comparable to the results from the R-M treatments in Yr 1 and Yr 2. Redfearn et al. (2002) illustrated spring productivity of ryegrass over a 2-yr trial at four locations and reported that mean concentration of NDF in ryegrass across the growing season was 48.5%; which is comparable to the treatments containing ryegrass in the present study. Increasing fiber constituents are expected with increasing plant maturity during the grazing season.

Mean TDN concentrations both years significantly decreased over the grazing season ($P < 0.0001$ for both Yr 1 and Yr 2, respectively). In Yr 1 and Yr 2, mean TDN concentrations ranged from 83.5 to 65.4% and 81.5 to 57.6%, respectively, from late January through early spring. The TDN requirement for a 280 kg growing steer is 63% (NRC, 2000), which is well within the treatment range reported in this study. Ball et al. (2015) stated that TDN concentration of ryegrass declines from a range of 68 to 63% in the vegetative-boot stage to a range of 63 to 59% in the boot-head stage, which was observed in the R-M and R-E treatments in both Yr 1 and Yr 2. Thus, the mean TDN values from the combinations of cool-season annuals used in the present study are sufficient for stocker cattle production.

Table 15. Mean chemical composition of cool-season annual mixtures during the 2015 grazing season. All data are presented as percent of DM.

Item	Treatment[1]				
	R-O	R-M	R-E		
	---------------	% DM basis	---------------	Mean	SE
CP	19.8	19.8	19.6	19.7	0.54
ADF	25.8	26.6	26.6	26.3	0.52
NDF	48.4	49.2	49.4	49.0	0.75
TDN	73.2	72.3	72.2	72.6	0.60

[1]R-O = rye and oats; R-M = rye and Marshall ryegrass; R-E = rye and Earlyploid ryegrass.

Table 16. Mean chemical composition of cool-season annual mixtures during the 2016 grazing season. All data are presented as percent of DM.

Item	Treatment[1]				
	R-O	R-M	R-E		
	---------------	% DM basis	---------------	Mean	SE
CP	16.9[a]	15.0[b]	17.3[a]	16.4	0.42
ADF	25.9[b]	29.0[a]	26.3[b]	27.1	0.56
NDF	50.4[b]	54.7[a]	50.6[b]	51.9	0.68
TDN	73.0[a]	69.5[b]	72.6[a]	71.7	0.64

[1]R-O = rye and oats; R-M = rye and Marshall ryegrass; R-E = rye and Earlyploid ryegrass.
[a,b,c] Within a row, means differ ($P < 0.10$).

Table 17. Date effects for mean chemical composition of cool-season annual mixtures during the 2015 grazing season. All data are presented as percent of DM.

Sampling Date	Crude Protein	Acid Detergent Fiber	Neutral Detergent Fiber	Total Digestible Nutrients
	---------------	% DM basis		---------------
1/30/15	26.0[a]	16.7[e]	36.4[e]	83.5[a]
2/13/15	20.5[b]	20.8[d]	41.6[d]	78.9[b]
2/27/15	17.9[c]	26.4[c]	49.3[c]	72.5[c]
3/13/15	16.4[d]	35.1[a]	60.3[a]	62.6[e]
3/27/15	17.8[c]	32.5[b]	57.3[b]	65.4[d]
SE	0.65	0.65	0.91	0.74

[a,b,c,d,e] Within a column, means differ ($P < 0.10$).

Table 18. Date effects for mean chemical composition of cool-season annual mixtures during the 2016 grazing season. All data are presented as percent of DM.

Sampling Date	Crude Protein	Acid Detergent Fiber	Neutral Detergent Fiber	Total Digestible Nutrients
	---------------	% DM basis		---------------
1/25/16	21.9[a]	18.5[d]	38.1[d]	81.5[a]
2/4/16	21.5[a]	25.5[c]	48.6[c]	73.5[b]
2/18/16	15.7[b]	25.4[c]	49.8[c]	73.6[b]
3/3/16	11.3[c]	30.9[b]	59.8[b]	67.3[c]
3/21/16	8.7[d]	39.4[a]	69.7[a]	57.6[d]
SE	0.53	0.66	0.83	0.75

[a,b,c,d] Within a column, means differ ($P < 0.10$).

Steer initial, final, and ADG from the cool-season annual mixture treatments

Animal response variables for Yr 1 and Yr 2 for the cool-season annual treatments are presented in Tables 19 and 20, respectively. Mean initial BW in Yr 1 and Yr 2 did not differ among treatments (P = 0.3977 and P = 0.1162, respectively). Among all treatments in Yr 1 and Yr 2, mean final BW did not differ significantly (P = 0.2382 and P = 0.3644, respectively). In Yr 1 and Yr 2, there were no significant differences in ADG among treatments as well (P = 0.2130 and P = 0.4534, respectively). Although, when looking at only the initial and final BW for both Yr 1 and Yr 2 there are no differences, however, there is a noticeable difference between the years with respect to ADG. This may be partially explained by the variation in total number of grazing days in each year and compensatory gain effects. In Yr 1, there was an average of 57 grazing days across all treatments. In Yr 2, there was an average of 37, 42, and 44 grazing days achieved for the R-E, R-O, and R-M treatments, respectively. Forage availability is the primary factor that influenced the number of grazing days among years.

Parish (2011) explains that compensatory gain occurs when nutrient intake returns to sufficient levels and usually is triggered after relatively short periods of nutrient restriction. In the present study, the steers on test during the warm-season phase experienced an unintentional nutrient restriction, so when put on the cool-season test, compensatory gain was experienced. In Yr 1 during the first 27-d period grazing the cool-season treatments, the steers gained on average 0.4 kg/d, while in Yr 2 during the first 28-d period grazing the cool-season treatments, the steers gained on average 1.6 kg/d. This noticeable difference of compensatory gain in Yr 1 and Yr 2 partially explains the difference observed in Yr 1 and Yr 2 ADG.

Results from a 3-yr grazing trial in Arkansas revealed that spring ADG of stocker calves on R-RG was 19% greater that that of cattle grazing oats (Beck et al., 2005). Beck et al. (2007)

conducted a study that evaluated cool-season annual grasses overseeded into a bermudagrass sod for stocker cattle and observed that rye produced the greatest ADG in spring (1.17 kg/d) among all the species tested. Cleere et al. (2004) reported that steers grazing a combination of rye + ryegrass gained between 1.01 and 1.28 kg/d from December to May across two stocking rates and grazing systems in Overton, TX. Values for ADG from the present study were less than from these evaluations in Yr 1, but similar to or greater than those reported in Yr 2.

In both Yr 1 and Yr 2, there were no significant differences in G/ha (P = 0.2242 and P = 0.1355, respectively) across treatments. In Yr 1, the mean G/ha was 196 kg/ha, which was lower than Yr 2 that achieved a mean G/ha of 227 kg/ha. In Yr 1, the average stocking rate across all treatments were 4.13 steers/ha (5 steers/paddock). In Yr 2, the average stocking rate for R-M and R-E were 4.13 steers/ha, but R-O only supported a stocking rate of 3.03 steers/ha (3.67 steers/paddock). Due to the forage availability in the R-O treatments, the fixed stocking rate of 4.13 steers/ha was not achieved. However, greater ADG in Yr 2 is largely attributed to the observed difference in G/ha. These data indicate that the lesser amount of forage availability in Yr 2 influenced the grazing days, as well as, allowing those steers to maintain the forage at a vegetative state. This may have aided to the steers in Yr 2 experiencing a higher level of compensatory gain and the difference in G/ha among years.

Table 19. Average daily gain, initial, and final body weight and G/ha of steers grazing cool-season annuals for Yr 1.

	Treatment[1]			
Item	R-O	R-M	R-E	SE
Initial BW, kg	286	291	288	2.62
Final BW, kg	328	337	343	5.82
ADG, kg	0.50	0.55	0.66	0.06
Gain/ha, kg	173	187	228	21.44

[1]R-O = rye and oats; R-M = rye and Marshall ryegrass; R-E = rye and Earlyploid ryegrass.

Table 20. Average daily gain, initial, and final body weight and G/ha of steers grazing cool-season annuals for Yr 2.

	Treatment[1]			
Item	R-O	R-M	R-E	SE
Initial BW, kg	284	282	286	1.15
Final BW, kg	350	344	341	4.05
ADG, kg	1.56	1.41	1.49	0.08
Gain/ha, kg	199	255	228	16.72

[1]R-O = rye and oats; R-M = rye and Marshall ryegrass; R-E = rye and Earlyploid ryegrass.

Conclusions

Results from this study indicate that cool-season annual forages such as small grains and annual ryegrass may be planted in mixtures and used effectively as cover crops within a row crop system. The mixtures of ryegrass and small grains used in this study had a similar growth distribution early in the late winter/early spring months and maintained high nutritive value throughout the grazing season. The nutritive value of grazed mixtures supported reasonable ADG in Yr 1 and exceptionally higher ADG in Yr 2. The number of grazing days and compensatory gain may explain differences in ADG in Yr 1 compared to Yr 2. Steers grazing rye mixtures achieved a reasonable ADG without additional supplementation to available forage. These results suggest that early-maturing Florida 401 rye, when grown in combination with annual ryegrass, may provide a feasible option for a short-term grazed cover crop system in South Alabama and produce comparable forage mass, nutritive value, and animal performance to small grain rye-oats mixture. Future research in this area may focus on methods for improving forage utilization within a fixed stocking rate system, since a fixed stocking rate it the most commonly used practice. However, the information derived from these two years is especially useful to beef and/or row crop producers in South Alabama who may be interested in developing a systems approach to management in their operation.

Literature Cited

Aiken, G.E. 2016. Invited Review: Grazing Management Options in Meeting Objectives of Grazing Experiments. The Professional Animal Scientist 32:1-9.

Aiken, G.E. 2002. Cost of steer weight gain to rate of supplementation with ground corn on bermudagrass pasture. Agron. J. 94:1387-1392.

Akin, D.E. 1989. Histological and physical factors affecting digestibility of forages. Agron. J. 81:17-25.

Alabama Livestock-Poultry-Grain Market News. May 14, 2016. Alabama Department of Agriculture and Industries. Vol No. 253 Issue No. 253.

Allen, V.G., C. Batello, E.J. Berretta, J.Hodgson, M. Kothmann, X. Li, J. Mclvor, J. Milne, C. Morris, A. Peters, and M. Sanderson. 2011. An international terminology for grazing lands and grazing animals. *Grass and Forage Science*, *66, 2-28* (Blackwell Publishing Ltd.).

American Meat Institute. 2008. BSE: Testing - What It Can and Cannot Accomplish. Washington, D.C. 20036.

Anderson, S.J., J.K. Merrill, and T.J. Klopfenstein. 1988a. Soybean Hulls as an Energy Supplement for the Grazing Ruminant. J. Anim. Sci. 66:2959-2964.

Anderson, S.J., J.K. Merrill., M.L. McDonnell, and T. J. Klopfenstein. 1988b. Digestibility and utilization of mechanically processed soybean hulls by lambs and steers. J. Anim. Sci. 66:2965-2976.

Anderson, S.J., T.J. Klopfenstein, and V.A. Wilkerson. 1998. Escape protein supplementation of yearling steers grazing smooth brome pastures. J. Anim. Sci. 66:237-242.

Anderson, J.D., C. Lacy, C. Forrest, and R. Little. 2003. Stocker cattle ownership vs. contract grazing: a comparison of risk-adjusted returns. Selected Paper Southern Agriculture Economics Association. In: SAAS-SAEA Annual Meeting, 2012. Mobile, AL.

Bagley, C.P., J.C. Carpenter, Jr., J.I. Feazel, F.G. Hembry, D.C. Huffman, and K.L. Koonce. 1987. Influence of calving season and stocking rate on beef cow-calf productivity. J. Anim. Sci. 64:687-694.

Ball, D.M., C.S. Hoveland, and G.D. Lacefield. 2015. *Southern Forages* (Fifth Edition). Peachtree Corners, Georgia 30092-2844: International Plant Nutrition Institute (IPNI).

Ball, D.M., M. Collins, G.D. Lacefield, N.P. Martin, D.A. Mertens, K.E. Olson, D.H. Putnam, D.J. Uundersander, and M.W. Wolf. 2001. Understanding Forage Quality. American Farm Bureau Federation Publication 1-01, (Park Ridge, IL).

Beck, P.A., M. Anders, B. Watkins, S.A. Gunter, D. Hubbell, and M.S. Gadberry. 2013. 2011 and 2012 Early Careers Achievement Awards: Improving the production, environmental, and economic efficiency of the stocker cattle industry in the southeastern United States. J. Anim. Sci. 91:2456-2466.

Beck, P.A., C.B. Stewart, J.M. Phillips, K.B. Watkins, and S.A. Gunter. 2007. Effect of species of cool-season annual grass inter seeded into Bermudagrass sod on the performance of growing calves. J. Anim. Sci. 85:536-544.

Beck, P.A., D.S. Hubbell, K.B. Watkins, S. A. Gunter, and L.B. Daniels. 2005. Performance of stocker cattle grazing cool-season annual grass mixtures in northern Arkansas. The Prof. Anim. Sci. 21:465-473.

Beck, P.A., M. Anders, B. Watkins, S.A. Gunter, D. Hubbell, and M.S. Gadberry. 2013. Improving the production, environment, and economic efficiency of the stocker cattle industry in the southeastern United States. J. Anim. Sci. 91:2456-2466.

Blok, E. Rumen Microbial Protein Production: Are We Missing an Opportunity to Improve Dietary and Economic Efficiencies in Protein Nutrition of the High Producing Dairy Cow? High Plains Dairy Conference 2006, Industry Presentation.

Blount, A.R. and G.M. Prine. 2012. Annual Ryegrass. SSAGR88, UF IFAS extension.

Blount, A.R., J. M. B. Vendramini, J.C.B. Dubeux, M.A. Babar., K.E. Kenworthy, P. R. Munoz, and K.H. Quesenberry. 2014. 2014 Cool-Season Forage Variety Recommendations for Florida. SS-AGR-84, UF IFAS Extension.

Bowman, J.G.P. and D.W. Sanson. 1996. Starch- or fiber-based energy supplements for grazing ruminants. Proc. West. Sec. Amer. Soc. Anim. Sci. 47: (suppl.1):118-135

Bransby, D.I., B.E. Conrad, H.M. Dicks, and J.W. Drane. 1988. Justification for grazing intensity experiments: analysis and interpreting grazing data. J.Range Manage. 41:274-279.

Bruckner, P.L. and R.L. Raymer. 1990. Factors influencing species and cultivar choice of small grains for winter forage. J. Prod. Agric. 3:349-355.

Burns, J.C. and D.S. Fisher. 2007. Dry Matter Intake and Digestibility of ‘Coastal’, ‘Tifton 44’, and ‘Tifton 85’ Bermudagrass Hays Grown in the U.S. Upper South. Crop. Sci. 47:795-810.

Burton, G.W., R.N. Gates, and G.M. Hill. 1993. Registration of “Tifton 85” Bermudagrass. Crop Sci. 33: 644-645.

Buxton, D.R. and S. L. Fales. 1994. Plant environment and quality. P. 155-199. *In* Fahey, G.C. (Ed.) Forage quality, evaluation, and utilization. ASA, CSA, SSSA, Madison, WI.

Caton, J.S. and D.V. Dhuyvetter. 1997. Influence of energy supplements on grazing ruminants: requirements and responses. J. Anim. Sci. 75:533-542.

Chase, C.C., Jr. and C. A. Hibberd. 1987. Utilization of low-quality native grass hay by beef cows fed increasing quantities of corn grain. J. Anim. Sci. 65:557-566.

Cleere, J.J., F.M. Rouquette, Jr., and G.M. Clary. 2004. Impact of stocking rate and stocking strategy on gain per hectare of steers grazing rotational or continuous stocked rye-ryegrass pasture. J. Anim. Sci. 87 (Suppl. 1):292.

Coppock, C.E., J. K. Lanham, and J. L. Horner. 1987. A review of the nutritive value and utilization of whole cottonseed, cottonseed meal, and associated by-products by dairy cattle. Animal Feed and Technology. 18:89-129.

Cosgrove, D., M. Casler., and D. Undersander. Ryegrass types for pasture and hay. Agronomy Advice FC 14.12.2 Dec 1999.

Evers, G.W., L.A. Redmon, and T.L. Provin. 2004. Comparison of bermudagrass, bahiagrass, and kikuyugrass as a standing hay crop. Crop Sci. 44:1370-1378.

Galloway, D.L., Sr., A.L. Goetsch, L.A. Forster, Jr., A.C. Brake, and Z.B. Johnson. 1993a. Digestion, feed intake, and live weight gain by cattle consuming bermudagrass and supplemented with different grains. J. Anim. Sci. 71:1288-1297.

Galloway, D.L., Sr., A. L. Goetsch, L. A. Forster, Jr., R. Patil, W. Sun, and Z.B. Johnson. 1993b. Feed intake and digestibility by cattle consuming bermudagrass or orchardgrass hay supplemented with soybean hulls and(or) corn. J. Anim. Sci. 71:3087-3095.

Hafley, J.L. 1996. Comparison of marshall and surrey ryegrass for continuous and rotational grazing. J. Anim. Sci. 74:2269-2275.

Hafley, J.L., B.E. Anderson, and T.J. Klopfenstein. 1993. Supplementation of growing cattle grazing warm-season grass with proteins of various ruminal degadabilities. J. Anim. Sci. 71:522-529.

Hancock, D.W. 2014. At-A-Glance: Rye. CSS-F013, UGA Extension.

Hancock, D.W. 2014a. At-A-Glance: Annual Ryegrass. CSS-F012, UGA Extension.

Hancock, D.W. 2014b. At-A-Glance: Oat. CSS-F014, UGA Extension.

Hancock, D.W., R.C. Lacy, and R.L. Stewart Jr. September, 2011. Forage Systems for Stocker Cattle. UGA Cooperative Extension Bulletin 1392.

Hill, G.M., R.N. Gates, and G.W. Burton. 1993. Forage quality and grazing steer performance from Tifton 85 and Tifton 78 bermudagrass pastures. J. Anim. Sci. 71:3219-3225.

Hill, G.M., R.N. Gates, and J.W. West. 2001. Advances in bermudagrass research involving new cultivars for beef and dairy production. J. Anim. Sci. 79(E-Suppl.):E48-E58.

Hoveland, C.S. 1986. Beef-forage systems for the southeastern United States. J. Anim. Sci. 63:978-985.

Horner, J. and J. Sexton. 2015. By-Product Feed Price Listing. University of Missouri Extension.

Hunt, C.W., J.F. Parkinson, R.A. Roeder, and D.G. Falk. 1989. The delivery of cottonseed meal at three different time intervals to steers fed low-quality grass hay: effects on digestion and performance. J. Anim. Sci. 67:1360-1366.

Janovick N.A., J.R. Russell, D.R. Strohbehn, and D.G. Morrical. 2004. Productivity and hay requirements of beef cattle in a Midwestern year-round grazing system. J. Anim. Sci. 82:2503-2515.

Jennings, J., K.Simon, P. Beck, S. Gadberry, S.M. Jones, T. Troxel, and D.Philipp. 2009. Grazing stockpiled forages to reduce hay feeding during fall and winter. Agriculture and Natural Resources, FSA3133-PD-4-12RV (University of Arkansas Research and Extension).

Jensen, K.B., B.L. Waldron, K.H. Asay, D.A. Johnson, and T.A. Monaco. 2003. Forage nutritional characteristics of orchard grass and perennial ryegrass at five irrigation levels. Agron. J. 95:668-675.

Johnson, J.M. and D.M. Ball. 2013. Alabama Planting Guide for Forage Grasses. ANR-0149, Alabama Cooperative Extension System.

Johnson, J.M. and K. Mullenix. 2014. A quick guide to grazing methods. Timely Information ACES, Agronomy & Natural Resources (F 2014-5).

Jung, H.G. and M.S. Allen. 1995. Characteristics of plant cell walls affecting intake and digestibility of forages by ruminants. J. Anim. Sci. 73:2774-2790.

Karges, K.K., T. J. Klopfenstein, V.A. Wilkerson, and D.C. Clanton. 1992. Effects of Ruminally Degradable and Escape Protein Supplements on Steers Grazing Summer and Native Range. J. Anim. Sci. 70:1957-1964.

Klopfenstein, T. 1996. Need for escape protein by grazing cattle. Animal Feed Science Technology 60:191-199.

Kunkle, W.E., J.T. Johns, M.H. Poore, and D. B. Herd. 2000. Designing supplementation programs for beef cattle fed forage-based diets. J. Anim. Sci. 77:1-11.

Lalman, D.L., C.M. Taliaferro, F.M. Epplin, C.R. Johnson, and J.S. Wheeler. 2000. Review: Grazing stockpiled bermudagrass as an alternative to feeding harvested forage. J. Anim. Sci. 79:1-8.

Mandebvu, P., J.W. West, G.M. Hill, R.N. Gates, R.D. Hatfield, B.G. Mullinix, A.H. Parks, and A.B. Caudle. 1999. Comparison of Tifton 85 and Coastal bermudagrass for yield, nutrient traits, and digestion by growing beef steers. J. Anim Sci. 77:1572-1586.

Marchant, K.B., R.B. Muntifering, S.P. Schmidt, and L.W. Greene. Stocker Cattle Performance from Grazed Mixtures of Triticale and Wheat with Ryegrass. Thesis. 2014.

Martin, S.K. and C.A. Hibberd. 1990. Intake and digestibility of low-quality native grass hay by beef cows supplemented with graded levels of soybean hulls. J. Anim. Sci. 68:4319-4325.

McKinley, B., J. Parish, R. Watson, J. Anderson, T. Engelken, and B. White. 2004. Stocker Production in Mississippi. Cattle Business in Mississippi, “Stocker Cents” article.

McCartor, M.M. and F. M. Rouquette., Jr. 1977. Grazing Pressures and Animal Performance from Pearl Millet. Agron. J. 69:983-987.

McCollum, F.T. and M. L. Galyean. 1985. Influence of cottonseed meal supplementation on voluntary intake, rumen fermentation and rate of passage of prairie hay in beef steers. J. Anim. Sci. 60 (2) 570-577.

McNamee, C.E., R. Muntifering, L. Kriese-Anderson, and L.W. Greene. Stockpiled ‘Tifton 85’ Bermudagrass for Cow-Calf Production as Influenced by Nitrogen Fertilization. Thesis. 2014.

Merten, G.C. and R. M. Jordan. 1972. Put-and-take vs. fixed stocking for defining three grazing levels by lambs on alfalfa-orchardgrass. Agron. J. 64:69-72.

Mullenix, M.K., E. J. Bungerstab., J. C. Lin, B. E. Gamble., and R. B. Muntifering. 2012. Productivity, quality characteristics, and beef cattle performance from cool-season annual forage mixtures. Prof. Anim. Sci. 28:379-386.

Mullenix, M.K., S.L. Dillard, J.C. Lin, B.E. Gamble, and R.B. Muntifering. 2014. Evaluation of wheat and triticale forage for stocker production in the Gulf Coast region. Prof. Anim. Sci. 30:296-304.

Myer, B., A. Blount, C. Mackowiak, and R. Barnett. 2011. Suitability of Triticale, either as a mono-crop or in a blend with annual ryegrass as pasture forage for grazing by growing beef cattle during the cool season. UF/IFAS Beef Cattle Report.

National Cattlemen’s Beef Association. 2006. Fact Sheet: Feedlot Finishing Cattle. The Beef

Checkoff.

Nelson, C.J. and L.E. Moser. 1994. Plant factors affecting forage quality. P115-154 *In* Fahey, G.C. (Ed.) Forage quality, evaluation, and utilization. ASA, CSA, SSSA, Madison, WI.

Nicholas, D. 2009. Eat more oats.

Oelke, E.A., E.S. Oplinger, H. Bahri, B.R. Durgan, D.H. Putnam, J. D. Doll, and K.A. Kelling. 1990. Alternative Field Crops Manual: Rye. Univ. Wisconsin and Minnesota Cooperative Extension Service.

Parish, J. 2011. Compensatory Gain in Cattle. Drovers Cattle Network.

Prigge, E.C., W. B. Bryan, and E. L. Nestor. 1997. Sward height on performance of cow-calf units and yearling steers grazing cool season pasture. Grazing Management 29:97-98.

Redfearn, D.D., B.C. Venuto, W.D. Pitman, M.W. Alison., and J.D. Ward. 2002. Cultivar and environment effects on annual ryegrass forage yield, yield distribution, and nutritive value. Crop Sci. 42:2049-2054.

Rouquette, M. 2005. The power of bermudagrass: 1,000 pounds of gain per acre. Pasture Gazette, Volume 1(Issue 1).

Russell, J.B. 2002. *Rumen Microbiology and Its Role in Ruminant Nutrition*. Ithaca, NY.

Sanson, D.W. 1995. What is the best energy supplement for thin cows on low-quality roughages? Range Beef Cow Symposium, paper 194.

Scaglia, G. and H.T. Boland. 2014. The effect of bermudagrass hybrid on forage characteristics, animal performance, and grazing behavior of beef steers. J. Anim. Sci. 92:1228-1238.

Scarbrough, D.A., W.K. Coblentz, K.P. Coffey, J.E. Turner, G.V. Davis, D.W. Kellog, and D.H. Hellwig. 2002. Effects of summer management and fall harvest date on ruminal in situ degredation of crude protein in stockpiled bermudagrass. Animal Feed Science and Tech. 96:119-133.

Schuster, D., D. Undersander, D. Schaefer, R. M. Klemme, M. Siemens, and L. Smith. 2001. Stocker Enterprise Budgets for Grass-Based Systems. University of Wisconsin Extension. A3718.

Sleper, D.A. and J.M. Poehlman. (2006). *Breeding Field Crops* (Fifth edition). Blackwell Publishing.

Sollenberger, L.E., J.E. Moore, V.G. Allen, C.G.S. Pedreira. 2005. Reporting Forage Allowance in Grazing Experiments. Crop Sci. 45:896-900.

Sprott, L.R., G.E. Selk, and D.C. Adams. 2001. Review: Factors affecting decisions on when to calve beef females. Prof. Anim. Sci. 17:238-246.

Subcommittee on Beef Cattle, C. on A. N., & Board on Agriculture, N.R.C. (2000). *Nutrient Requirements of Beef Cattle* (Seventh). Washington, D.C.: National Academy Press.

Troxel, T.R. and B.L. Barham. 2012. Phenotypic expression and management factors affecting the selling price of feeder cattle sold at Arkansas livestock auctions. Prof. Anim. Sci. 28: 64-72.

Winger, H., D.R. Zobell, and K.C. Olson. 2006. Supplementation of Energy and Protein for Beef Cattle, A Literature Review. Utah State University Extension, AG/Beef/2006-01.

Wheeler, J.S., D.L. Lalman, G.W. Horn, L.A. Redmon, and C.A. Lents. 2002. Effects of supplementation on intake, digestion, and performance of beef cattle consuming fertilized, stockpiled bermudagrass forage. J. Anim. Sci. 80:780-789.

Wright, T. and R. Lackey. 2008. Definitions of feed manufacturing and livestock nutrition terms. 08-039.

Van Soest, P.J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: voluntary intake in relation to chemical composition and digestibility. J. Anim. Sci. 24:834-843.

Van Soest, P.J. 1994. Nutritional ecology of the ruminant. 2nd ed. Cornell University Press, Ithaca, NY.

Vendramini, J.M.B., L.E. Sollenberger, J.C.B. Dubeux, Jr., S.M. Interrante, R.L. Stewart, Jr., and J.d. Arthington. 2006. Concentrate supplementation effects on forage characteristics and performance of early weaned calves grazing rye-ryegrass pastures. J. Crop. Sci. 46:1595-1600.