MANAGEMENT STRATEGIES AND LIVE WEIGHT GAIN OF STEERS GRAZING OLD WORLD BLUESTEM AND SUBSEQUENT FEEDLOT PERFORMANCE AND CARCASS CHARACTERSTICS

By

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NOMENCLATURE

ADG	average daily gain
BW	body weight
cm	centimeters
CP	crude protein
d	day
DIP	degradable intake protein
DM	dry matter
DMI	dry matter intake
GAIN	individual animal weight gain
GHA	gain per hectare
h	hour
ha	hectare
HIES	half intensive early stocking
IES	intensive early stocking
SL	season long grazing
SLS	season long grazed and late summer protein supplementation
SD	standard deviation
kg	kilogram
^{o}C	degrees centigrade
yr	year

Chapter I

Introduction

The southern Great Plains is a vast sea of native and introduced forages that provide the backbone for cattle grazing programs. Beef production is highly dependent on the abundant and relatively cheap gains that can be obtained from utilizing these forages. Old World bluestem is a warm season grass that has become a larger part of Oklahoma forage systems since its introduction in the early 1900's. Old World bluestem has been used quite extensively in reclaiming marginal farmland and seeding land enrolled in the Conservation Reserve Program (CRP) (Dewald et al., 1985). Thus, gaining a better understanding of how to utilize OWB is important to the continued success of Oklahoma beef production.

Grazing programs are used throughout the country to add economical weight and skeletal growth to cattle. Winter and summer forages allow producers varied opportunities to match cattle age and type with available forages to achieve animal gain. Warm season grasses and more specifically introduced grasses allow exceptional potential for summer gains of over two pound per animal per day. Old World bluestem provides a great deal of high quality vegetative material in the early summer, which demonstrates the need to utilize that growth. Other warm season grasses encounter a similar problem in that they decline in nutritive value and digestibility as the growing season progresses. In order to continue adequate animal gains it may be necessary to provide protein supplementation during this period to make up for the decreased protein content of the forages.

No matter the forage system used in the United States the ultimate destination of calves and yearlings is the feedlot. Grain feeding is used to improve flavor and tenderness of beef and is the predominant system of cattle finishing in this country. However, grain feeding can also be a costly part of the production system depending on grain and cattle prices, thus managing cattle to achieve the greatest gains in the shortest amount of time is crucial for financial success of feedlots and producers. Therefore, knowing how cattle were previously managed is important for achieving maximum animal performance in the feedlot and on the rail.

The first objective of this study was to evaluate a grazing program that could utilize the large amounts of high quality vegetative forage available from Old World bluestem in the early growing season. The grazing program that best fit the growth pattern of OWB was intensive early stocking. Ackerman et al. (2001) found that increased stocking rates allow for better utilization of the growth potential of Old World bluestem as compared with rates typically used on native tallgrass prairie. Intensive early stocking is the doubling of the stocking density of an area of forage for half of the typical season long grazing period. By utilizing this system the amount of cattle can be increased to harvest the forage as it becomes available and avoid the aggressive growth pattern that results in a mature grass that is lower in nutritive value.

A second objective of this study was to evaluate the effectiveness of supplementing cattle grazing Old World bluestem with a high protein supplement late in the summer. Dabo et al. (1987) found that as the season progressed Old World bluestem declined in nutritive value. The supplementation program was designed to mimic the Oklahoma Gold Program that supplies a 40% crude protein supplement fed at one pound per animal per day during the late summer. The Oklahoma Gold supplementation program supplies protein to a native grass system that is typically deficient in protein. Although Old World bluestem does not decline as rapidly as native prairie pastures the decline does occur and it has been suggested that protein supplementation on Old World bluestem would be effective in producing additional cattle weight gains (Forwood et al., 1988).

The final objective was to evaluate the effects of previous grazing management decisions on animal performance in the feedlot and final carcass characteristics.

Chapter II

Review of Literature

Old World Bluestem

Old World bluestem has become part of the landscape in many parts of the southern Great Plains. This warm season, perennial grass originated in Europe and Asia and was first brought to the United States in the late 19th and early 20th century (Celarier and Harlan, 1955). Old World bluestems are known for their superiority to native species in production, quality, grazing persistence, and response to nitrogen fertilizer (Dabo et al., 1987). In addition their ease of establishment has proven them to be the primary grass used in reclaiming marginal farmland and controlling erosion in Oklahoma and western Texas (Dewald et al., 1985). The majority of the acres of Old World bluestem that have been established are enrolled in the Conservation Reserve Program (CRP). The vast acreages that have been planted have created the need for additional information on how to manage Old World bluestem and the opportunity to utilize these warm season bunch grasses for beef production is excellent (Dewald et al., 1985).

The majority of the Old World bluestems used in Oklahoma are Caucasian, Granada, King Ranch, WW-Spar, WW-Iron Master, and Plains (Hodges and Bidwell, 1993). Plains bluestem originated from (Bothriochola ischaemum (L.) Keng. var. ischaemum) and was a blend of parent materials from 30 varieties collected in Afghanistan, Pakistan, India, Turkey, Iran, Kashmir, Iraq, and many parts of southern Asia (Taliaferro et al., 1972). The blending of parental strains allowed for greater adaptability and survival under various climates and soil conditions. Plains bluestem has been established on thousands of acres across Oklahoma because of its longer grazing season and greater adaptability than other cultivars (Hodges and Bidwell, 1993).

Growth Pattern

Old World bluestem begins growth in late April and provides excellent grazing potential by late May and early June (Dewald et al., 1985) and will be in a mature stage with seed head by early July (Berg and Sims, 1995). Forage production is typically complete by late July, but additional growth will occur in the late summer with adequate precipitation (Hodges and Bidwell 1993). Nutritive values of Old World bluestem declined as it matured (Dewald et al., 1985) due to the increase in the amount of fiber found in the plant and the effects of increased ambient temperature (Dabo et al., 1988). Dabo et al. (1988) concluded that stage of maturity had a larger impact on forage nutritive value than did culitvar. This was established by Dabo et al. (1987) after invitro dry matter digestiblity declined more rapidly in stems than in leaves with the same trend appearing across cultivars. Dabo et al. (1988) reported that leaves contained less fiber and more crude protein than stems and thus were more digestible at all stages of growth. Therefore, the quality of Old World bluestem must be kept in mind while managing cattle for maximum grazing performance during the summer. Quality and digestibility can be dramatically affected by advancing maturity of Old World bluestem (Dabo et al., 1988; Berg and Sims, 1995).

One means of harvesting the vegetative and high quality growth that occurs in the early grazing season would be to utilize intensive early stocking (Dewald et al., 1985). Coleman and Forbes (1998) found that Old World bluestem supports outstanding early season gains due to its growth pattern and vegetative qualities but gains declined as summer progressed because of the lower nutritive value of the grass. Phillips and Coleman (1995) established that increased stocking densities in the early season did effectively utilize the rapidly growing vegetation and reduce the incidence of patch grazing on Old World bluestem. Teague et al. (1996) found intensive grazing to achieve short pasture height produced increased live leaf to stem ratios and decreased the amount of dead material, which resulted in higher crude protein values. The effectiveness of increased stocking density for utilizing OWB is evident, but increased grazing pressure requires greater stocker cattle management to take advantage of summer gain potential on Old World bluestem (Berg and Sims, 1995).

Response to environment and grazing pressure

Old World bluestem has rapid growth potential that aids in seed development and reproduction. Yet, it also has the ability to conserve energy in root reserves after severe defoliation or drought stress, which allows it an adaptability advantage for survival (Coyne and Bradford, 1985). Old World bluestem quickly produces a leaf canopy early in the growth cycle, yet the energy expended on those leaves is minimal. Thus, by effectively utilizing this growth pattern Old World bluestem has successful establishment and tolerance for severe defoliation (Coyne and Bradford, 1985). Coyne and Bradford (1985) also reported that Old World bluestem under drought stress produced more tillers, leaves, and leaf area per plant than native species despite the fact that native species were taller and had larger leaves. Coyne and Bradford (1985) concluded that this ability to conserve energy will not make OWB the top producer every time but it will allow the plant to remain viable in very unfavorable conditions.

In a testament to the adaptability and survivability of Old World bluestems, Eck and Sims (1984) found that after 36 years of survival on the High Plains of the Texas panhandle, yellow and Caucasian bluestems dominated their own test plots as well as all other plots in the study. Dabo et al. (1987) findings agreed that Old World bluestems in their native habitats proved to be a secondary succession species rather than a climax species thus demonstrating their ability to take advantage of any situation.

Grazing can have a dramatic impact on any grass, but Plains bluestem has the ability to handle it better than most grasses due to its prostrate growth structure as opposed to the upright structure of Caucasian bluestem (Forbes and Coleman, 1993). Svejcar and Christiansen (1987) determined that the severity of grazing has a huge impact on root length and mass yet the amount of variation between heavy and light grazing pressure on total root mass of Old World bluestem in the upper soil profile was not dramatically different. Svejcar and Christiansen (1987) also concluded that even with decreased root length, heavily grazed plants were able to retain a greater root to leaf ratio, which improved water status and toleration of continuous heavy grazing as compared with lighter grazed plants. Conversely, Teague et al. (1996) found that decreased stubble height decreased root biomass of WW-Spar bluestem and prolonged patterns of severe defoliation could decrease stand viability.

Production potential

Plains bluestem is very responsive to nitrogen fertilization and will produce forage yields from 2 to 6 tons per acre over a wide variety of soil types despite preferring a fine textured soil (Taliaferro et al., 1972). Berg (1993) reported that ammonium nitrate and urea in increasing amounts increased the amount of forage produced regardless of soil type. Although, fertility without adequate precipitation is futile as established by Hodges and Bidwell (1993) who found increased production response from Old World bluestem with increasing amounts of fertilizer and adequate amounts of precipitation. Bezanilla and Villalobos (1999) also concluded that forage production and live weight gain per unit area increased on a continuous grazing system that was provided adequate amounts of precipitation. Berg and Sims (1995) reported improvements in individual animal performance with increased amounts of nitrogen fertilizer. Short-term production responses have been well established but the longevity of Old World bluestems was supported by two bluestems that survived a 36-year trial in Dallam County, Texas (Eck and Sims, 1984). Eck and Sims (1984) found introduced bluestems had the highest forage yields of any of the remaining grasses that could still be identified as dominating their respective plot in a large multi-grass study.

Possible alternatives for utilizing Old World bluestem include interseeding with legumes and deferment grazing with native prairie during the summer.

Interseeding offers alternatives for grazing management programs by allowing grazing earlier in the season before Old World bluestem is typically ready for production. Interseeding with legumes also allows for the reduction in the use of nitrogen fertilization, which is becoming more important with the current concerns about environmental quality. Volskey et al. (1996) established that using legumes in a grazing management system does require more attention to timing of grazing and deferment of plants to allow for reseeding of stand. Gunter et al. (1994) proposed the use of Old World bluestem in a rotational grazing system for western Oklahoma. Native prairie typically declines in nutritive value in the late summer whereas OWB crude protein and digestibility never declines quite as far as native and thus offers an alternative for summer grazing (Gunter et al., 1994).

Factors affecting stocker performance

The Oklahoma prairie provides vast opportunity for cattle production. Stockers arrive from all over the country to be grown on the rich cool and warm season forages found in America's heartland. With the current condition of the cattle industry it is possible to find calves that are born throughout the year in various parts of the country. Being born in different locations with different management strategies provides a wide assortment of calves varying in type and condition. The environment and weight gain that the calves experience during the first winter away from their dam can have a dramatic impact on subsequent performance.

Rate of gain

Winter typically presents a harsh environment and will result in the most challenging time of year for a cattle operation and often leads to high feed and labor costs. The location within the country makes a large impact on the exact wintering program that will be utilized. The Northern Plains often utilize cornstalks where as the Southern Plains typically use some type of planted cool season annual. Another popular program used quite extensively is wintering light weight cattle on some type of dormant forage and supplementing in order to achieve some targeted rate of gain. The amount of weight that cattle are able to gain can have a major impact on subsequent summer grazing performance. Baker et al. (1992) found that when cattle were maintained on a low plane of nutrition in the winter, greater body protein gain occurred during the subsequent summer.

Lawrence and Pearce (1964) reported that Sussex x Shorthorn cross steers grown at .03 lb/d and .74 lb/d during the winter demonstrated the greatest compensatory gain (2.64 lb/d and 2.16 lb/d, respectively) over the subsequent summer, while steers with the highest winter gain (1.61 lb/d) achieved the poorest summer gains at 1.25 lb/d. The low winter gain cattle did not surpass the high gain steers in total weight production, but they did recover the greatest amount of weight (370 vs 175 lb, respectively) compared with the high winter gain group over a 150 day grazing period. White et al. (1987) discovered similar results with steers that were wintered in drylot on bermudagrass hay or on winter wheat in order to adjust the winter rate of gain to achieve a lose of .23 kg/d or gain up to .71 kg/d. The high winter gain steers had the lowest and the low winter gain cattle had the highest summer gains grazing grass and legume mixed pastures. Contradictory to other studies, Tucker et al. (1989) evaluated steers wintered at two rates of a gain on perennial, cool-season grass and legume hay with a corn and soybean meal supplement. The wintering treatments were not severe enough to cause differences between the two groups, thus the initial summer trial weights were similar and subsequently it was determined that summer average daily gain was not affected by winter rate of gain. Lewis et al. (1990a) examined wintering programs from an economic standpoint and determined that when cattle were grown for enhanced winter gain the amount of gain that occurred the following summer was limited. The increased wintering costs decreased the financial feasibility of the growing system.

Another factor that has a huge impact on the amount of gain achieved by cattle that have had restricted growth is the diet fed following the restriction. Mader et al. (1989) surmised that the extent to which compensatory gain is realized was affected by the diet consumed during the realimentation period. White et al. (1987) concluded the variability in compensatory gain following growth restriction was due to the amount and duration of the restriction and the diet following the restriction. Thus for a producer to take full benefit from realimentation they should be very cognoscente of the diet being utilized.

Stocking Rate

Another factor that can and will affect the amount of gain an animal is able to achieve is stocking rate. Phillips and Coleman (1995) reported when utilizing summer grazing systems based on warm season grasses individual animal results were relatively similar but gain/acre achieved was totally dependent on stocking rate. Harlan (1958) found in a review of multiple grazing studies that gain per animal decreased as stocking rate increased. Hart et al. (1988) reported average daily gain declined as stocking rate increased on native prairie in Wyoming with rotational grazing systems. Coleman and Forbes (1998) also found that individual animal gains declined as stocking rates increased and available forage decreased for steers grazing OWB. Hart et al. (1988) concluded that gain per unit area, stocking rate, and individual animal performance can be increased to a critical point, and after that point is reached increasing any one factor will do so at the other factors expense. Ackerman et al. (2001) reported that average daily gain declined as stocking rate increased for steers grazing Old World bluestem due to decreased forage intake, increased grazing time, and decreased available forage mass, yet increased stocking rates resulted in greater gain per hectare. Ackerman et al. (2001) also established that when utilizing Old World bluestem, increased stocking rates lead to better utilization of the pastures than what is typically found on native tallgrass prairie.

Intensive Early Stocking

Intensive early stocking is doubling the amount of cattle grazing a unit of forage for half the amount of time typically utilized in a season long grazing system. The concept has existed for almost three quarters of a century as demonstrated by Black et al. (1937) who found that aged Hereford steers grazed on native short grass prairie in South Dakota and stocked at 1.3 hectare per steer for the first half of a 140-day grazing season had 38% greater gain per hectare than steers stocked at 5.7 hectare per steer for the entire grazing season. Intensive early stocking programs allow cattle to consume forage at its peak nutritive value (Owensby et al., 1995). Intensive early stocking by definition would appear to contradict the conclusions that increased stocking rate decreases animal performance, yet intensive early stocking is accepted because of increased gain per hectare without decreased individual animal performance and the lack of negative impact on plant production (Owensby et al., 1995). This is in agreement with Dewald et al. (1985) who reported that intensive early stocking works well to harvest early season growth that is very vegetative and high quality. Volesky et al. (1994) also concluded that increased stocking densities in the early season effectively utilized the rapidly growing vegetation and reduced the incidence of patch grazing on Old World bluestem. Yet for the commercial cattleman the theory behind a production system may not be as important as the cost associated with the system. Bernardo and McCollum (1987) compared intensive early stocking to season long grazing and determined from the economic analysis that season long stocking is safer when gain potential and selling prices of cattle are low. They also proposed that intensive early stocking requires rapid animal gain and elevated selling prices in order to recapture operating costs associated with shorter days of ownership. Bernardo and McCollum (1987) also reported the concept commonly held by producers that older cattle with greater capacity for weight gain are needed in order to maximize performance from an IES system. A four-year study of intensive early stocking versus season long grazing allowed McCollum et al. (1990) to demonstrate that rapid early season gains are possible with IES. In that study IES cattle achieved 65% of the gains per hectare in half the grazing days of season long cattle on native tallgrass prairie. The intensive early stocking system produced 19% more beef for the total season than did season long grazing due to the increased gain per hectare of the IES steers.

With the gain potential offered by the use of intensive early stocking the use of forage species with greater production potential than that offered by native species should be evaluated. Phillips and Coleman (1995) assessed grazing systems and determined that introduced species are more variable in their production potential and cost but the opportunity for increased animal performance is exceptional when compared with native range. Phillips and Coleman (1995) also reported that Old World bluestem had a higher cost associated with producing forage but when those costs were expressed in dollars per animal, OWB had a lower production cost than native tallgrass prairie because of the increased stocking rate. An additional benefit of utilizing intensive early stocking is the opportunity to harvest forages at the peak of their nutritive value (Owensby et al., 1995).

<u>Cattle type</u>

Cattle type can also effect performance from birth to finishing. Owensby et al. (1988) found that changing from multiple source, medium frame British cross cattle to single source, large framed British x Zebu cross cattle that individual animal performance and gain per hectare were increased. Lusby et al.

(1985) found that when evaluating performance from Hereford and Hereford x Angus cross steers that crossbred steers gained .22 lb/d faster during late summer supplementation than purebred steers. Cattle age can also play a major role in the expression of growth. Lawrence and Pearce (1964) determined that the older an animal is at the time of nutrient restriction the greater the likelihood that they will achieve complete compensatory gain. Grings et al. (1996) evaluated calves and yearlings sired by bulls with differing amounts of growth potential and determined that calves had lower summer average daily gain than yearlings yet ate more as a percent of body weight. Also it was determined that high growth potential yearlings tended to have greater organic matter intakes than did steers sired by bulls with moderate growth potential when expressed as kg/day.

Grazing systems

Grazing systems are as varied as the people that design them and this variability is reflected in cattle performance. Hart et al. (1988) found that average daily gain declined as stocking rate increased on native prairie in Wyoming with rotational grazing systems. Cantrell et al. (1985) observed that rotational grazing improved ADG of light weight Angus cross calves as compared with continuous grazing with no supplementation in the late summer on bermudagrass pasture. Bezanilla and Villalobos (1999) on the other hand found that forage production and live weight gain per unit area on irrigated Old World bluestem increased with adequate amounts of precipitation on a continuous grazing versus a rotational system. The results of these trials are consistent with most results that find any given system, in any given location, with any given set of growing conditions can produce different amounts of forage production and animal performance. Drouillard and Kuhl (1998) concluded from a review of grazing studies that production techniques can be implemented to alter grazing performance without vastly effecting subsequent carcass merit.

Supplementation prior to feedlot

Forage protein levels typically decline on native pastures in the late summer (Lusby et al., 1982). A means of combating the summer "slump" that ensues because of decreased forage protein level is to implement some type of supplementation program. Cantrell et al. (1985) reported that protein supplementation on bermudagrass late in the season when forage quality was significantly decreased, produced greater gains than no supplementation (1.25 vs .95 lb/d, respectively). Shoop and McIlvain (1971) determined that late summer supplementation with a 41% cottonseed cake increased individual animal weight gain of Hereford steers on native range. Lusby et al. (1982) also found that supplementation in the late summer increased average daily gain of steers fed a high protein supplement vs control cattle that received no supplement. Lusby et al. (1983) concluded that protein supplementation of British bred steers with a 39% protein cube resulted in greater ADG and supplement conversion than control and energy supplemented cattle in the late summer. Gill et al. (1984) also determined that late summer supplementation with a 38% protein cube improved ADG by .95 lb/d as compared to unsupplemented control steers.

The practicality of a system has a huge impact on its usefulness and effectiveness to producers. Owensby et al. (1995) evaluated energy supplementation for steers on an intensive early stocking program and determined supplement conversions were marginal on grass and questionable as to whether they would be useful in a grazing program. This emphasizes the importance of utilizing programs that are relevant and targeted for a given situation.

Feedlot Performance

The feedlot is the endpoint for the majority of the beef cattle produced in the United States. These cattle are born throughout the country and are raised in a wide variety of environments. With this wide and varied background, subsequent finishing performance can be altered by numerous environmental and management scenarios. Weight gain achieved prior to the feedlot can affect placement weights and thus affect subsequent finishing performance and carcass merit.

Effects of previous rate of gain

Heinemann and Van Keuren (1956) fed Hereford steers in drylot for 155 days at three rates of targeted winter gain, and then grazed irrigated cool season pastures for 155 days. Their findings are in agreement with later experimenters who determined that cattle, which gained the greatest amount of weight per day in the winter had the lowest summer gains and conversely low winter gain cattle gained the most in the summer. Heinemann and Van Keuren (1956) also concluded from their experiment wintering treatments had no effect on feedlot performance following the grazing season. Lewis et al. (1990b) determined that cattle managed with different rates of winter gain had similar feedlot performance and subsequently there was no performance benefit to pushing cattle for gains greater than .28 kg/d during the winter. Although, they did find that steers with higher winter average daily gains had numerically greater feed intake and average daily gain than cattle managed for medium and low rates of winter gain. Lewis et al. (1990b) also concluded that by the end of the summer the winter weight differences had been equalized across treatments and summer rate of gain did not have an effect on feedlot performance. White et al. (1987) reported that steers with different rates of winter gain were basically not different in their feedlot performance, although steers with greater winter gain required fewer days on feed to finish.

Other more extensive studies have been evaluated to determine the effects of previous nutrition on cattle performance. Ridenour et al. (1982) evaluated five different growing schemes for crossbred steers in northeastern New Mexico. Cattle that were fed for the entire experimental period on a high concentrate diet were designated (HC), steers fed a 50% concentrate diet to 273 kg and then fed a high concentrate to finish were (50C-273), and steers fed a 50% concentrate diet to 364 kg and then fed a high concentrate to finish were (50C-364). Steers that grazed irrigated wheat pasture to 273 kg and then fed a high concentrate to finish were (WP-273), and steers that grazed irrigated wheat pasture to 364 kg and then fed a high concentrate to finish were (WP-364).

Because of the growing treatment, the HC cattle had fewer DOF, higher ADG, and better F:G prior to the feedlot than all other treatments. In the finishing phase the HC cattle and the steers that were grown to 273 kg took longer to finish but were more efficient and had greater gains than steers grown to 364 kg on either the 50% concentrate ration or the wheat pasture growing program. Mader et al. (1989) grew heifers on three systems: directly to feedlot at weaning (1), backgrounded on cornstalks for 111 days and then to feedlot (2), and cornstalks then cool season grass for 116 days then to feedlot (3). Despite different placement times for systems 2 and 3, finishing phase feed conversions were similar (.122 vs .123 gain/feed). System 3 heifers had greater ADG and DMI than heifers from system 2. Mader et al. (1989) concluded that different growing systems offer great potential to alter feedlot performance by modifying previous nutrition and that intake was influenced more by animal age than weight because older heifers consumed more feed than younger heifers at a common weight.

The effects of previous nutrition are not limited to the winter and thus the gain achieved in the summer can have a large impact on subsequent cattle performance. Gill et al. (1991) evaluated crossbred steers that were program fed for 84 days prior to intensive early stocking or season long grazing of native tallgrass prairie. Intensive early stocked steers consumed less feed (25.1 vs 29.2 lb DM/d), had similar ADG (4.13 vs 4.17 lb/d), and were more efficient (6.05 vs 6.93 feed/gain) than SL cattle. However, an interaction was identified for winter and summer grazing treatments indicating that winter feeding affected summer performance. Gill et al. (1992) looked at feedlot performance of heifers that were backgrounded during the winter and grazed on IES or SL summer grazing strategies. In the feedlot IES cattle consumed less feed (22.2 vs 23.6 lb DM/d), had better ADG (3.8 vs 3.38 lb/d), and lower F:G (5.83 vs 6.99 lb feed/ lb gain) than SL heifers. Gill et al. (1992) concluded that prolonged summer grazing results in reduced feedlot efficiencies.

Effects of prior supplementation

Winter and summer gains are not the only factors that will affect feedlot efficiencies. Summer supplementation can alter cattle gains on summer grass and subsequently future performance. Perry et al. (1971) determined that increasing amounts of energy supplementation during the summer increased ADG on grass, however for each additional kg of gain on grass the steers subsequently gained .2 kg less per day in the feedlot. Perry et al. (1972) concluded from a four-year study that increasing amounts of energy supplementation on cool season grasses decreased ADG in the feedlot, and also decreased the number of days on feed required to achieve a choice carcass. Perry et al. (1972) also found that the total amount of feed required for the entire production system of summer supplementation through the feedlot was greater for the cattle that were supplemented in the summer than for unsupplemented steers. Lake et al. (1974) was in agreement with earlier findings that concluded increasing amounts of energy supplementation on irrigated cool season pastures in Nebraska resulted in a linear increase in ADG on grass and decreased the number of days on feed required to finish steers. Owensby et al. (1995)

evaluated sorghum supplementation, intensive early stocking, and subsequent feedlot performance of steers grazing native tallgrass prairie. Daily gain, feed intake, and gain/feed ratios were not different between the supplemented and unsupplemented cattle, and the weight differences present at the initiation of the feeding phase remained throughout trial. Denham (1977) evaluated energy and protein supplementation for steers grazing native shortgrass prairie and ryegrass pastures. Steers that were protein supplemented while on grass had better feed conversions and gained more weight in the feedlot than unsupplemented steers. In contrast, steers that were energy supplemented on grass had lower ADG and poorer feed conversions in the feedlot than unsupplemented steers. In summary, energy supplementation during the summer appears to have a negative effect on feedlot performance although it does seem to shorten the number of days needed to finish cattle. Protein supplementation on the other hand appears to improve feedlot performance although this is only accounted for in one study.

Carcass Merit

The carryover effects from a previous growing system can influence the next phase of the production cycle and that impact can also be seen in carcass characteristics. Understanding the importance of proper management in each stage of an animal's life is vital to the continued success and advancement of animal agriculture.

Effects of prior growing programs

White et al. (1987) concluded that steers placed on feed at the end of the winter trial had heavier carcasses, higher quality grades, higher marbling scores, and greater fat depth than steers that were finished following summer grazing; yet overall carcass composition was minimally affected by wintering treatment. Lewis et al. (1990b) also reported that winter and summer treatments had no affect on carcass composition. Ridenour et al. (1982) evaluated five different growing schemes and determined that there were basically no differences in carcass traits except for dressing percent, kidney, heart, and pelvic fat, and ribeye area for all growing treatments. Ridenour et al. (1982) also concluded that the HC treatment, had higher DP, KPH, and ribeye areas than all other treatments, and that quality grades increased with time on feed.

Owensby et al. (1995) determined that intensive early stocking and sorghum supplementation of steers grazing native tallgrass prairie did not affect carcass quality. Gill et al. (1991) demonstrated steers, which grazed the entire summer had heavier carcasses, higher percent choice, higher marbling scores, and higher numerical yield grades than steers that were grazed utilizing an intensive early stocking program. Gill et al. (1992) repeated the trial from the previous year and again concluded that season long grazed heifers had heavier carcass weights, higher marbling scores, higher percent choice, and higher numerical yield grades than intensive early stocked heifers. In evaluating types of growing systems and their subsequent effects on cattle performance, Mader et al. (1989) reported that heifers wintered on cornstalks and then finished as compared with heifers that were wintered in the same manner and then grazed on cool season pastures prior to the feedlot had no differences in carcass traits.

Effects of prior supplementation

Lake et al. (1974) evaluated the effects of energy supplementation on carcass characteristics and determined that carcass traits were not affected by level of energy supplementation. Lake et al. (1974) also established that increasing amounts of energy supplementation during the summer decreased the number of days on feed for the feeding period. In contrast to previous work, Owensby et al. (1995) concluded that hot carcass weight increased with increasing amount of energy supplementation. Denham (1977) evaluated protein supplementation of Hereford and Hereford cross steers grazing native shortgrass prairie. Steers that received protein supplementation had heavier carcasses and greater percentage of choice carcasses than steers, which received no supplementation. Thus, research demonstrates that depending on the system and the differences created by that system results can be quite varied both in the feedlot and in the carcass.

Summary of Review of Literature

The importance of grazing programs and good management in cattle production is without dispute and it is imperative to the success of producers that rely on those programs. Old World bluestem has demonstrated its usefulness and sustainability in the southern Great Plains, and will continue to offer outstanding opportunities for success in cattle production. The importance of good grass management is evident when utilizing OWB, and thus continued research to optimize utilization and production will add to the usefulness of this grass. Optimizing the use of forage supplies is crucial, but understanding cattle management is critical to the economic success of a ranching entity.

Cattle backgrounds vary greatly and the importance of establishing programs that fit the animal is imperative for taking advantage of the growth potential that any given set of cattle offers a producer. Winter backgrounding or growing programs appear to have a large impact on subsequent grazing performance. Steers that were held or grown for marginal gain during the winter consistently gained the greatest amount of weight during the following summer. Conversely, steers targeted for large winter gains demonstrated the lowest summer gains. Summer gains can also be altered by various summer grazing strategies and thus affect feedlot performance and carcass value. The reviewed research supports the programs that are already being used by producers striving for the greatest return on their investment. Differences in performance can be obtained from any growing or grazing program; but as a whole, the feeding phase diminished prior differences and thus created a more uniform finished live product. The feeding phase also helps to diminish differences seen between carcasses from animals grown prior to the feedlot on varied growing and grazing programs. Research that evaluates all components of systems for growing cattle and grass are vital for the continued success of animal agriculture. Additionally, understanding how the pieces of a puzzle fit together is and will continue to be important as American agriculture moves into the 21st century.

Grazing and supplementation programs provide vast opportunity and versatility for stocker growing systems.

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CHAPTER III

MANAGEMENT STRATEGIES AND LIVE WEIGHT GAIN OF STEERS GRAZING OLD WORLD BLUESTEM AND SUBSEQUENT FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS

P.D. Kircher, H.T. Purvis II, G.W. Horn, C.J. Ackerman, and T.N. Bodine

ABSTRACT: A two year study utilizing at total of 755 crossbred steers (237 ± 25 kg) grazing Plains OWB were used to determine the effects of various grazing and management systems of cattle on animal performance. Additionally, during year two the effects of different grazing and management systems were evaluated on subsequent feedlot performance and carcass merit. Steers were weighed and allotted to one of four treatments with three replicates per treatment on May 12. Treatments were: 1) intensive early stocking (IES: stocking density of 1344 kg BW/ha; 67d grazing season); 2) half intensive early stocking (HIES; 672 kg BW/ha, 67d of grazing); 3) season long (SL; 672 kg BW/ha, 136d of grazing); and 4) season long supplemented (SLS; same stocking density as SL and fed 0.18 kg·steer^{-1}·d^{-1} of CP prorated for 3x/week feeding from July 19 – Sept. 26). Following the grazing phase in year 2, 30 steers per treatment (July 20 – IES and HIES; September 28 – SL and SLS) of average ADG and BW were selected from each pasture as a subsample of each treatment and placed in the feedlot and fed to a common endpoint. Data were analyzed with the MIXED procedure of SAS (1999) in a randomized complete block design with block included as a random effect. A significant treatment x year interaction was observed for early gain per hectare (GHA) and thus data were reported by year.

Intensive early stocked steers had lower ADG and individual animal gain (GAIN) ($P < 0.001$) than HIES, SL, and SLS steers. Half intensive early stocking, SL, and SLS had similar ($P = 0.18$) ADG and individual animal gain during the early season (May 12 – July 19). Year 1 GHA for IES was lower (115 vs 167 kg/ha; $P < 0.01$) than SLS but tended to be similar to SL and HIES (157 and 133 kg/ha; $P = 0.06$). Year 2 early GHA for IES was greater (258 vs 201, 187, and 189; $P < 0.006$) than HIES, SL, and SLS. In the early season of year two, HIES, SL, and SLS had similar ($P = 0.41$) GHA. In the late season (July 20 – Sept. 26) and the total season SLS cattle had greater ($P < 0.02$) ADG, GHA, and gain/steer than SL. Initial feedlot weights were different for IES, HIES, SL, and SLS ($P < 0.03$; 297, 309, 361, and 373 kg). Season long steers had greater DMI ($P < 0.02$) than HIES and IES. Feed efficiency was similar for IES, HIES, and SL ($P = 0.22$); however, all three treatments had greater gain/feed ratios than SLS ($P < 0.05$). Percent choice was similar ($P = 0.28$) for all treatments, however season long steers indicated a trend ($P < 0.06$) for a greater percent choice than early season steers. Kidney, heart, and pelvic fat was greater for SLS and SL than IES and HIES ($P < 0.03$). Intensive early stocking was an effective management tool for maximizing gain/ha if growing conditions were adequate to provide ample forage in the early season. Supplementation during late summer grazing improved individual steer performance and gain/ha. Feedlot performance was similar for IES and SL thus demonstrating that either program can serve as an effective management tool without negative impact on carcass merit.

Key words: Growing Cattle, Old World bluestem, Grazing, Feedlot

Introduction

Old World bluestem has been used quite extensively in reclaiming marginal farmland and controlling erosion in Oklahoma and Texas (Dewald et al., 1985; Berg, 1993). Old World bluestem provides a great deal of high quality forage in the early summer, yet it declines in nutritive value and digestibility as the growing season progresses (Dabo et al, 1987, Coleman and Forbes, 1998). Evaluating management systems that utilize Old World bluestem throughout its life cycle by matching grazing schemes with forage nutritive value would increase the usefulness of this grass. One method that offers potential for harvesting early season vegetative growth of Old World bluestem may be intensive early stocking (Coleman and Forbes, 1998). Intensive early stocking works well for grazing systems because animals harvest forages during their highest nutritive value while still maintaining adequate gains (Owensby et al., 1995). The need to deal with late season declines in crude protein of Old World bluestem could be addressed by implementing a late summer protein supplementation program. Late summer supplementation programs supply protein to tallgrass prairie that typically is deficient in protein (Lusby et al., 1982). Although, the protein content of Old World bluestem does not drop as rapidly as native prairie pastures, the decline does occur and protein supplementation on Old World bluestem may be effective in producing additional cattle weight gains (Forwood et al., 1988). The objective of our study was to evaluate intensive early stocking and late season supplementation effects on steers grazing Old World bluestem and assess subsequent feedlot performance and carcass merit.

Materials and Methods

Grazing Research Site

This research was conducted at the Bluestem Research Range 11 km southwest of Stillwater, OK. The primary soil types at this site are: Coyle Loam, Coyle-Lucien complex, Grainola-Lucien complex, Renfrow loam, Stephenville-Darnell complex, Stephenville fine sandy loam, and Zaneis loam. Plains Old World bluestem (*Bothriochloa ischaemum L. Keng:OWB*) was established on the site in 1989. Total precipitation for the months of May, June, July, August, and September was 56.7 cm in 1999 and 41.2 cm in 2000. The historical average precipitation for this site during these months is 55.0 cm. Each spring nitrogen fertilizer was applied at a rate of 103 kg N/ha and herbicide (Grazeon P+D®, 2,4-D + Picloram, Dow AgroSciences, Indianapolis, IN) was applied in the spring of 1999 only. Before the start of the trial in 2000, soil samples were taken to establish limiting nutrients other than nitrogen. The test results showed no deficiencies in soil nutrients and subsequently nitrogen fertilizer was applied at the same rate as in year one. The site has a total of 105 ha of OWB that is divided into 12 paddocks that are approximately 8.7 ha in size. A winter grazing study and receiving cattle were used to remove all dormant vegetation and equalize initial standing crop across pastures.

Feedlot Research Site

The feedlot phase of this study occurred only in year two and was conducted at the Willard Sparks Beef Research Center located west of Stillwater, OK. Pens were 4.6 m wide by 9.1 m long with an automatic waterer placed in the fenceline between every other pen. An open sided shed covered the feed alley, bunk pad and the bunk for all pens in that alley. The pens have a one-time capacity of five head that allows each animal 0.9 m of bunk space. Steers were moved to new pens as their current pens became so muddy that it threatened their health and the integrity of the trial.

Treatment Design

Year 1. Three hundred and ninety-five crossbred steers with an average initial weight (225 ± 20 kg SD) were randomly assigned to one of four treatments. Treatments were 1) intensive early stocking (IES; stocking density of 1344 kg/ha and a 67d grazing season); 2) half intensive early stocking (HIES; 672 kg/ha, 67d of grazing); 3) season long (SL; 672 kg/ha, 136d of grazing); and 4) season long supplemented (SLS; same stocking density as SL and fed 0.18 $kg \cdot steer^{-1} \cdot d^{-1}$ of CP (DM basis) prorated for 3x/week feeding from July 21 – Sept. 28). The supplement was 40% CP and made of 80.5% cottonseed meal, 11.5% soybean meal, and 8% wheat middlings. The trial was initiated on May 12, 1999 and final weights for IES and HIES were taken on July 20, 1999. The SL and SLS treatments were weighed on July 21, 1999 to determine performance on the first half of the trial and on September 28, 1999 to establish off trial weights. All cattle weights during both years of the grazing study were attained after a 12-16 hour overnight shrink in an attempt to equalize fill across treatments. The steers were removed from access to feed and water in a small drylot area.

Year 2. Three hundred and sixty crossbred steers with an initial weight of (249 ± 23 kg SD) were randomly assigned to one of four treatments. The initial stocking densities and treatment designations were the same as for Year 1 except SLS steers were fed 0.18 $kg \cdot steer^{-1} \cdot d^{-1}$ of CP (DM basis) prorated for 3x/week feeding from July 19 – Sept. 23. The supplement used in year 2 contained only 35% CP on a DM basis; thus, the quantity fed was increased to deliver a similar amount as in year 1. The trial was initiated on May 12, 2000 and final weights for IES and HIES were taken on July 17, 2000. Season long and season long supplemented treatments were weighed on July 18, 2000 for a mid weight and on September 25, 2000 for a final weight.

At initial processing, steers received doramectin (Dectomax®, Pfizer Animal Health, Exton, PA) at 1.5-ml/45.4 kg of body weight, an implant with 20 mg estradiol benzoate + 200 mg progesterone (Synovex-S®, Fort Dodge Animal Health, Overland Park, KS), and an individual identification number for both years. All treatments had ad-libitum access to water and white salt throughout the trial.

Feedlot

Ten steers from each pasture for a total of thirty head from each treatment were selected to enter the feedlot. The initial selection criterion was individual weight and average daily gain (ADG) relative to the pasture average. The selected individuals from each pasture were then randomly allotted to feedlot pen by treatment while maintaining pasture groups within pen. The goal of the selection procedure was to obtain pens that were similar to their respective pasture means for BW and ADG as well as being similar in type across the four treatments. The IES and HIES treatments entered the feedlot on the afternoon of July 19 and were processed at 0600 hours on July 20, 2000. The cattle had been held on grass with free choice access to native prairie hay after being weighed off the grazing trial in order to equalize fill and allow the cattle to rest after the post-grazing shrink. The season long cattle were process with the same procedure as the early season steers and were brought into the feedlot on September 27 and processed on September 28, 2000. At processing the steers received an implant with 24 mg estradiol 17β + 120 mg trenbolone acetate (Revalor-S®, Hoechst Roussel Vet, Clinton, NJ), a four-way respiratory vaccine, a seven-way clostridial vaccine, horns were tipped, and tails bobbed. The initial processing procedure was the same for both sets of steers. Initial feedlot weights were off trial weights for the grazing phase of the study. Steers of all treatments were weighed full and approximately every 35 days to observe performance during the trial. All cattle were weighed at 0600 hour prior to feeding and adjusted with a 4% pencil shrink. Steers were fed 48% of the days feed call at 0700 hr in the morning and the remainder of the days feed call at 1400 hr in the afternoon. Diets (Table 1) were made of whole shell corn, cottonseed hulls, alfalfa pellets, a protein supplement (Table 2), and blended yellow grease. Cattle received diet 1 for 7 days along with a decreasing amount of bermuda grass hay. Hay was fed at 1.4 $kg^{-1}\cdot steer^{-1}\cdot day^{-1}$ on day 1 and decreased by .23-$kg^{-1}\cdot day^{-1}\cdot steer^{-1}$ until completely taken out of the diet by day 7. Steers were moved up through three step up diets in order to reach the finishing diet that was fed for the remainder of the trial. Steers were moved up to the next diet when they had reached a target intake based on 70%, 85%, and 95% of their

calculated mean feed intake for the total feeding p
respectively. If the target intake was not reached w
were bumped on the seventh day to the next diet ir
adaptation to the finishing diet. Mean feed intake wa
((in weight x .014 + 10.2) x 1.2 / DM of the diet)
represents 120% and accounts for a theoretical 20%
to feeding whole shell corn. Diet 4 consisted of 79
supplement, 6.1% cottonseed hulls, 2.9% alfalfa pellet

Bunks were evaluated at approximately 2100 h
trial to accommodate the decreased animal activity
excessive summer heat. As evening temperatures coc
at approximately 1900 hours for the remainder of the tr
a system of 0 to 5 (Table 3) and the next days feed c
to the prior evenings bunkscore. Scores were mad
were verified by weighing the feed remaining in the b
sense of accuracy in the amount of feed that was visua

The IES and HIES cattle were weighed individu
prior to shipping on January 8, 2001. The feedlot
operational and the only available scales were on th
pens were weighed and ultrasounded on January 5th
remaining ten pens were weighed on the chute scales
were not brought up the second day to avoid added str
consecutive days and all IES and HIES steers were we

minimize the handling stress on the day of shipment. The average IES and HIES ultrasound fat measurement was compared to a two pen season long average measurement taken on February 2, 2001. The comparison was used as a gauge to estimate the additional number of days needed by the season long cattle to achieve a similar end point with the IES and HIES steers. Season long steers final weights were taken on February 13, 2001 prior to loading of trucks for transport to the harvest facility. The season long cattle were weighed on operational platform scales thus allowing final weights to be taken quickly and easily by pen the same day the cattle were shipped.

Carcass

Intensive early stocked steers were taken from their pens on the morning of January 8, 2001 and loaded on trucks for a 386.2 km trip to IBP Corp., Emporia, KS. Steers were weighed off trial and slaughtered the same day that they were shipped. Carcass data were collected on the grading line after a 24-hour chill by the Kansas State University carcass data collection service. The season long cattle were handled in the same manner and were weighed off trial on February 13, 2001. Hot carcass weights, marbling scores, quality grades, KPH, external fat thickness, ribeye areas, and final yield grade values were collected for both sets of steers. Marbling scores (i.e., Slight 40, Small 20, etc) were converted to a numerical scale (OSU Meats Judging Team Manuel) in order to analyze results. The quality grade "Small" Choice equaled 400 to 499 and Select equaled 300 to 399. To be considered upper two-thirds Choice a carcass equaled 500 or greater. Final live weights for both groups of steers were carcass weight divided by a common dressing percent of 62.5%. One steer was railed out at the harvest facility and was not included in the data set for the SLS treatment due to lack of information.

Sampling Procedures

Forage samples were collected and analyzed for nutritive values three times during year 1 and twice during the grazing season in year 2. Forage samples were collected on May 28, July 29, and September 28 and 30 in year 1 and on June 13 and 14 and August 17 and 18 in year 2. Year 1 forage samples were collected by hand plucking and ruminally cannulated steers were used to collect samples in year 2. Ruminally cannulated steers (average body weight: 635 ± 20 kg SD) were placed in the pastures approximately 7 days prior to each collection period to allow for adaptation to OWB. Forage samples were collected by removing reticuloruminal contents, allowing animals to graze for 1.0 to 1.5 h, then removing the masticate from the rumen and replacing reticuloruminal contents (Lesperance et al., 1960). Samples were taken using two animals per pasture and averaged together to obtain a forage nutritive value in year 2. Samples were taken during the mid-point of the first and second periods of the grazing season.

Forage mass collection techniques were the same for both years and forage mass was measured at the initiation, middle, and termination of the trial during both years. Six .1 m^2 quadrats were clipped by hand to approximately 2.5 cm of height in each pasture, and dried at 55°C and then allowed to air equilibrate prior to weighing.

Laboratory Analysis

Grass Samples: Oven dried masticate samples were ground in a Wiley mill to pass a 2-mm screen and were analyzed for DM and ash. Nitrogen content of masticate samples was analyzed using a combustion technique (Leco NS-2000, St. Joseph MI: AOAC, 1996). A 48-h in vitro procedure similar to the method of Goering and Van Soest (1970) was used to estimate masticate OMD. In order to determine OMD, 0.5 g of masticate sample was incubated in buffered ruminal fluid for 48 h. Samples were frozen at the end of the incubation period in order to halt microbial activity. Samples were thawed and an NDF extraction was performed on the residue and then the post-NDF residue was ashed to determine organic matter. The organic matter content of the original sample and the NDF residue were used to calculate in vitro OM disappearance. An in vitro protease procedure for forage samples was utilized to determine the amount of degradable intake protein (Roe et al., 1990) in the Old World bluestem masticate samples. Nitrogen disappearance was measured after a 48-hour incubation in a borate-phosphate buffer solution containing protease type XIV from Streptomyces griseus. This procedure was similar to that discussed by Roe et al. (1990) except the buffer pH utilized in this procedure was 7.8 rather than 6.7.

Feed Samples: Monthly samples of ration and ration ingredients were taken to determine dry matter, ash and nitrogen content. Oven dried feed samples were ground in a Wiley mill to pass a 2-mm screen. Nitrogen content of feed samples was analyzed using a combustion technique (Leco NS-2000, St. Joseph MI: AOAC, 1996).

Calculations

Initial, mid, and final weights were used to calculate average daily gain (ADG), individual animal gain (GAIN), and gain per hectare (GHA) for all treatments while on grass. Each of these variables were divided up into early season (initial weight to mid weight), late season (mid weight to final weight) and total season (initial weight to final weight for SL and SLS only). Individual animal gain (GAIN) was calculated as the change in weight from the start to the end of a grazing season. Average daily gain (ADG) was calculated as the total gain for a given season divided by the number of days in that season for a given treatment. Gain per hectare (GHA) was calculated as the amount of gain achieved during a given season divided by the appropriate hectares per pasture. Gain/feed ratios were calculated as the total amount of weight gained divided by the total amount of feed consumed on a dry matter basis.

Statistical Analysis

Steers were weighed and allotted in a randomized complete block design to one of four treatments with three replicates per treatment and repeated over two years. All data for year 1 and year 2 were analyzed in PROC MIXED of SAS (SAS Inst. Inc., Cary, NC); block was included as a random effect. Model included treatment, year, and treatment x year interactions. Block was included to account for the differences in pasture location and topography of those locations. Pasture was considered the experimental unit on grass and pen was considered the experimental unit in the feedlot. Data were pooled across years if no significant ($P < 0.05$) year x treatment interactions were observed. Least squares analysis and the P-DIFF option of SAS were used to separate treatment means when a significant (P < 0.05) *F*-value was observed.

Results and Discussion

Grazing Performance

Initial weights were similar between treatments (P = 0.17; Table 4), however steers were heavier in year 2 than in year 1. No significant treatment x year interactions (P = 0.07) were observed for early season ADG and GAIN and thus data were pooled and reported across year. Intensive early stocked steers had lower ADG (P < 0.001; Table 4) than all other treatments. Half intensive early stocking, SL, and SLS steers had similar ADG (P = 0.18) during early season. Coleman and Forbes (1998) and Ackerman et al. (2001) both concluded that individual animal gains declined with increasing stocking rates on Plains Old World bluestem due to decreased forage mass. Residual forage mass at the mid point of the trial was 3100 kg/ha lighter (Table 5) for the IES pastures versus the average of all other treatments. Coleman and Forbes (1998) and Ackerman et al. (2001) found comparable gains using cattle of similar size grazing Old World bluestem to those of our study (0.49 to 0.71 kg/d and 0.73 to 0.83 kg/d vs 0.51 to 0.93 kg/d, respectively), although stocking rates and grazing seasons were variable. Intensive early stocked steers weighed less than all other treatments (P < 0.001) at the mid point of the trial. Half intensive early stocking, SL, and SLS treatments had similar (P = 0.07) weights (Table 4).

During the late summer, SLS steers gained 0.11 kg/d more than unsupplemented steers (P < 0.009). Total ADG favored steers that were fed in the late summer with a high protein supplement as demonstrated by 0.08 kg/d greater gain ($P < 0.02$) than SL steers. Steers fed .36 kg/d of a 39% CP supplement while grazing tallgrass prairie in the late summer achieved 0.08 kg/d greater gain than control steers (Lusby et al., 1982). Grings et al. (1994) concluded that protein supplementation of cattle grazing native prairie of the Northern Great Plains was beneficial in adding additional weight without increased forage intake. Protein supplementation has been shown to improve, decrease, and have no effect on animal performance but typically it is suggested that it improves animal performance through increased digestibility, rate of passage, and intake, which results in increased energy consumption.

A significant treatment x year interaction ($P < 0.001$) was observed for early GHA and thus data were not pooled but reported by year. In year 1 early GHA for IES was lower ($P < 0.01$) than SLS but was similar to HIES and SL ($P = 0.06$). Half intensive early stocking GHA was similar to SL ($P = 0.31$); yet tended to be less than SLS ($P < 0.07$). Season long and SLS GHA were similar ($P = 0.36$). Residual forage mass for treatments stocked at 672 kg BW/ha in year 1 (Table 5) revealed no dramatic differences in available forage and nutritive values (Table 6) were actually greater for the HIES treatment as compared with season long treatments. During year 2 early GHA for IES was greater ($P < 0.006$) than HIES, SL, and SLS. Steers stocked at the lighter stocking density were similar ($P = 0.41$) in GHA for the early grazing period. Results of year 2 were more similar to those of McLean et al. (1990), Smith and Owensby (1978), and McCollum et al. (1990) findings with intensive early stocking. McLean et al.

(1990) determined IES steers had lower gain per animal than the SL steers, but produced 42.8% more weight per unit area than the SL. Smith and Owensby (1978) reported that gain per acre was doubled in the early season using IES as compared with season long stocking. In addition, IES steers produced 67% of the total weight gain achieved by the SL cattle in half the number of days. McCollum et al. (1990) reported that across a study that spanned four years, IES steers averaged 65% of the SL gains in the early season of grazing.

The treatment x year interaction resulted from drastic differences in weather encountered over the two years of the trial (Figure 1 and 2). In year 1, growing conditions in the late spring and early summer were cool and wet, which limited the growth of OWB and subsequently were limiting to cattle growth. In year 2, growing conditions allowed adequate forage production and consequently more acceptable animal performance. Precipitation totals for May, June, and July of year 1 were 2.7 cm more than in year 2 for the same months, yet timing of rainfall events varied drastically (Figure 3). May for both years received 10.2 cm of rainfall, yet June of 1999 had 12.4 cm more than June of 2000. July precipitation patterns were reversed from June with 9.8 cm less falling in 1999 than in 2000. Temperatures also varied between years and resulted in the last 9 days of May 1999 having 4.7 and 1.6 °C cooler ambient and sod temperatures, respectively, than May of 2000 (Figure 4). Thus cooler May temperatures and the timing of precipitation events in June lead to poorer growing conditions for OWB in 1999, ultimately limiting forage production and when coupled with heavy stocking rates restricted cattle performance.

The differences in the two years resembles differences seen by I et al. (1990) which demonstrated the sensitivity of the IES system importance of matching cattle type and growing conditions with the pı order to achieve success. Bernardo and McCollum (1987) evalı economic feasibility of intensive early stocking versus season long Estimates from the economic analysis indicated that season long stoc safer when gain potential was low. However, IES required rapid anir and elevated selling prices in order to recapture operating costs associ shorter days of ownership. They offered the theory that producers ı cattle with a greater weight gain potential in order to maximize or ca efficiency needed in an IES system. That theory was challenged thro done by Ackerman et al. (2001), which demonstrated gain poteı achievable with light or heavy weight cattle even at heavy stocking ra risk associated with IES was still very evident in our trial. Poor perfor the IES system in year 1 resulted from inadequate forage growing cı which compromised cattle performance, but year 2 resulted in IES gı 82% of the weight gain realized by the SL treatment in 65 days of grazi 2 demonstrates the point made by Bernardo and McCollum (1987) whe established that IES programs must achieve 60% of SL gains in orc financially feasible. Heavier stocking of OWB pastures allows for greɛ than native range. Average daily gain may decline as stocking rates incı GHA will increase mostly due to animals having less opportunity to be

(Phillips and Coleman, 1995). Increased stocking rates produced more GHA (Owensby et al., 1988).

Late GHA was greater for SLS steers with 23.4 kg/ha more than for SL steers (P < 0.008). Additional weight gain achieved through late summer supplementation allowed SLS steers to gain 33.1 kg/ha more weight than SL steers (P < 0.01). Late summer protein supplementation has been shown to be effective on native tallgrass prairie due to a decline in forage CP values during the late summer. Cattle grazing during this time frame are typically protein deficient. Lusby et al. (1982) achieved supplement conversions of 1.8 and 2.8 kg/ kg of additional gain when feeding high crude protein supplements in the late summer to steers grazing native tallgrass prairie. Steers grazing OWB during the late summer in year 1 gained an additional 8.1 kg and converted at 3.8 kg supplement/ kg of additional gain and in year 2 steers gained an additional 7.3 kg and converted at 5.3 kg supplement/ kg of additional gain. The differences in year and CP of the supplement could explain part of the supplement conversion differences between the two years. However, steer performance was not dramatically different between years and response to protein supplementation was still less than typically seen on native forages. Forage quality of native prairie versus OWB may prove to be a large portion of the differences seen in cattle response to supplementation. Old World bluestem typically does not decline in CP and digestibility as early in the growing season as native species. Basurto et al. (2000) reported that cattle with estimated microbial efficiencies of 9% were not deficient in degradable intake protein until mid-August on OWB whereas steers with the same efficiency on tallgrass prairie were deficient in mid-July. These findings mirror typical native prairie supplementation programs that begin supplementation in mid-July. Our trial followed the same feeding schedule as a native prairie supplementation program, yet if Basurto et al. (2000) were correct, cattle on OWB were not deficient in protein (Table 6) until later in the summer. Therefore starting protein supplementation in mid-July may be too early to achieve economical and efficient weight gain from cattle grazing OWB. Delaying the start date of supplementation would reduce the amount of supplement fed to cattle and possibly improve supplement conversions making supplementation more economically feasible for OWB. Additional weight can be generated on OWB from supplementation yet not to the same extent as supplementation programs on native prairie.

Feedlot Performance

Pen conditions deteriorated as the fall progressed into winter with the added influx of winter precipitation and freezing conditions. Pen conditions were quite unfavorable from the first major bout of winter precipitation on December 7th until the end of the trial. Intensive stocked steers and HIES steers spent roughly 19% of the feeding period in poor pen conditions whereas SL and SLS steers spent 49% of the feeding phase in poor pen conditions. The unfavorable pen conditions may have altered animal maintenance requirements and thus decreased animal gain and efficiency for all treatments, but most especially SL and SLS steers.

Intensive early stocked steers were lighter than all other treatments ($P < 0.03$; Table 7) at the initiation of the trial. Half intensive early stocked steers were also lighter than SL and SLS ($P < 0.001$). Season long steers weighed less than the SLS steers ($P < 0.05$) at the initiation of the feeding phase.

Final weights were not different ($P = 0.21$) between any of the treatments, but IES and HIES were numerically lighter than SL and SLS steers. Younger age and thus lighter placement weights of the IES and HIES treatments account for a portion of the weight difference between the early and late treatments (Gill et al. 1991, 1992). Season long steers gained more weight than SLS steers and were able to gain the 12 kg of weight that separated the two treatments at the start of the feedlot phase and then surpass the SLS steers to weigh 11 kg more at the end of trial.

Weight gain varied between treatments as would be expected with different ages and weights at placement. Intensive early stocked steers gained more total weight over the course of the feeding period than all other treatments, however IES and HIES were not different in total amount of weight gained ($P = 0.31$). Intensive early stocking and HIES both gained more weight ($P < 0.004$) than SL and SLS steers. The additional weight gain for the IES and HIES treatments was due to greater days on feed than season long steers. Season long steers gained more weight ($P < 0.03$) than SLS steers. The differences in efficiency and weight gain was also observed by Ridenour et al. (1982) who found steers put on feed at 273 kg after a short growing phase had increased weight gain and better feed/gain conversions than steers that were grown until 364 kg and then put on feed.

Average daily gain was similar across all treatments (P = 0.07), however IES, HIES, and SL had .14, .08, .16 kg/d greater gain than SLS steers. Perry et al. (1971) reported that increased amounts of energy supplementation on cool season grasses decreased ADG in the feedlot and also decreased the number of days on feed. Perry et al. (1971) also reported for each additional kg of gain on grass, steers subsequently gained .2 kg less per day in the feedlot. These results are similar to our findings of decreased ADG for SLS steers compared to all other treatments. Increased performance during the late summer tended to impair gain and efficiency in the feedlot for SLS steers.

Dry matter intakes per day were similar (P = 0.11) for IES and HIES, although IES consumed .45 kg/d more than HIES. Intensive early stocked steers also consumed similar amounts of feed per day as SLS steers (P = 0.23) and less than SL (P < 0.02). Half intensive early stocked steers had lower DMI than SL and SLS steers (P < 0.006). Early season steers had lower intakes than season long grazed steers which was supported by Mader et al. (1989) who concluded that feed intake was influenced more by age and previous nutrition than by animal weight because at similar weights older cattle ate more than younger cattle. Season long and SLS steer daily intakes were similar (P = 0.20) for the feeding phase. Perry et al. (1972) determined from a four year energy supplementation study that total feed required to finish summer supplemented Hereford steers was greater than for unsupplemented steers. This is contrary to our findings because total DMI was greater for SL steers than for SLS steers despite the poorer feed efficiencies of the supplemented steers.

Half intensive early stocked steers had greater gain/feed ratios ($P < 0.002$) than SLS steers. Gain/feed ratio for IES was similar ($P = 0.25$) to HIES and SL steers, but was greater ($P < 0.003$) than SLS steers. Season long grazed steers also had greater gain/feed ratio ($P < 0.05$) than SLS steers. Although gain/feed ratios were not different between IES and SL steers others have found different results when utilizing these grazing programs. Gill et al. (1991 and 1992) reported that steers and heifers that were grazed on an intensive early stocking program were more efficient than cattle grazed season long (5.8 vs 6.9 lb feed DM/ lb gain for heifers and 6.1 vs 6.9 lb feed DM/ lb gain for steers). Although the early cattle in our study were not statistically more efficient than season long cattle as shown through earlier studies, part of that difference may have been due to deteriorating pen conditions which may have compromised potential animal performance. Another portion of the efficiency difference could have also been associated with implanting the early season cattle only once during the feeding phase, which typically would have been implanted twice in a commercial setting due to age and weight at placement.

Our results for season long cattle were reversed from Denham (1977) who evaluated protein supplementation for steers grazing native shortgrass prairie and found that protein supplemented steers had better feed conversions and gained more weight in the feedlot than unsupplemented steers. Differences between studies could be due to length of supplementation, grass type, grass quality, and forage intake.

Carcass Characteristics

Carcass weights were similar (P = 0.20; Table 8) for IES, HIES, SL, and SLS treatments. Although differences were not statistically significant the early season steers had lighter carcasses than season long steers, which is a function of younger ages and lighter weights at placement in the feedlot. Gill et al., (1991 and 1992) concluded that no matter the sex of cattle, animals that grazed season long had heavier end weights and therefore heavier carcass weights than cattle grazed on an intensive early stocked program.

Marbling scores were similar for all treatments (P = 0.94). Percent choice and select in each treatment observed no differences (P = 0.28) between treatments as determined by Chi-square test. However, when analyzed for early versus late placement there was a strong trend (P = 0.06; Table 9) for season long grazed steers to have a greater percent choice than early grazed steers. In a review of management strategies that affect carcass parameters Owens and Gardner (2000), reported that marbling scores decreased and quality grades increased with heavier initial weights. Increased marbling scores also occurred with greater days on feed, which was evident in our trial as demonstrated by IES and HIES steers that were on feed for 34 additional days and had more carcasses with higher marbling scores than season long grazed steers.

All treatments had similar ($P = 0.06$) amounts of subcutaneous fat, however fat thickness increased in relation to the amount of time spent on grass. Season long grazed steers had greater fat deposition than did early season grazed steers and again this was supported by Owens and Gardner (2000) in their review that found advanced slaughter age was associated with greater amounts of subcutaneous fat. Ribeye area followed the same trend as fat thickness, as the number of days on grass and animal age increased so did ribeye size, yet again all treatments were similar in ribeye area ($P = 0.14$). Kidney, pelvic and heart fat demonstrated the greatest amount of variability for any of the carcass traits measured. Intensive early stocked steers had less ($P < 0.05$) KPH than all other treatments. Half intensive early stocked steers had a lesser amount ($P < 0.03$) of KPH than SL and SLS steers. Season long and SLS steers were similar ($P = 0.29$) in KPH, although SLS had numerically higher values than SL. Greater amounts of KPH fat tended to be associated with steers that were heavier at the initiation of the feeding phase and were grazed longer. However, contrary to our findings Owens and Gardner (2000) found that steers with greater initial weights and fewer days on feed had lower percent KPH. Also contrary to our findings, Ridenour et al. (1982) found REA and KPH declined as age and initial weight increased despite growing treatments. Yield grades were similar for all treatments ($P = 0.90$), yet IES had the lowest numerical YG of all treatments. Half intensive early stocked, SL, and SLS steers were stocked at the same density on grass and varied in their final yield grade by only 0.8%.

Carcass traits appear to have the least amount of variability among all measurements taken over the course of a growing program provided that initial differences were not drastically different. Lake et al. (1974) found that carcass traits were not affected by level of energy supplementation and when fed at increasing amounts it decreased days on feed. Klopfenstein et al. (2000) reported when ADG varied by .1 kg/d or less during the grazing phase there were no differences observed in the carcass, yet if ADG varied by more than .46 kg/d, the slower gaining cattle had greater days on feed, higher marbling scores, and greater percent choice carcasses. Drouillard and Kuhl (1998) concluded that grazing strategies can be implemented to alter performance without vastly affecting subsequent carcass merit. Differences found in the carcass appear to be less dramatic than those found during the grazing or feeding phases.

Implications

Intensive early stocking was an effective management tool for maximizing gain/ha during the early grazing period if growing conditions were adequate to provide adequate growth. Late summer protein supplementation produced additional weight gain on OWB yet not to the same extent as a native prairie supplementation program. Similar average daily gains and gain/feed ratios for intensive early stocked and season long grazed steers indicated that IES was an effective program for utilizing Old World bluestem and achieving acceptable animal performance. Late summer supplementation on Old World bluestem did not alter average daily gain or dry matter intake but it does appear to affect subsequent animal efficiency in the feedlot. Intensive early stocking and season long grazing provide different management options for cattle on Old World bluestem without impacting feedlot performance or carcass merit.

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Table 1. Ingredient and nutrient content of feedlot diets (DM basis)

Item	Ration 1	Ration 2	Ration 3	Ration 4
Ingredient composition				
Whole shell corn, %	60.00	70.00	79.00	79.00
Cottonseed hulls, %	15.00	10.00	5.00	6.10
Alfalfa pellets, %	15.00	10.00	5.00	2.90
Supplement, B110, %	8.00	8.00	8.50	9.00
Blended yellow grease, %	1.00	2.00	2.50	3.00
Nutrient composition[a]				
Crude protein, %	13.84	13.67	13.80	13.78
NE_m, Mcal/kg	1.89	2.03	2.15	2.16
NE_g, Mcal/kg	1.13	1.26	1.38	1.39
Fat, %	4.35	5.49	6.13	6.59
Crude fiber, %	12.68	9.18	5.69	5.68
Potassium, %	1.09	0.95	0.83	0.81
Calcium, %	0.69	0.61	0.56	0.55
Phosphorus, %	0.33	0.34	0.36	0.36
Magnesium, %	0.15	0.14	0.14	0.14
Sulfur, %	0.16	0.16	0.16	0.15
Cobalt, ppm	0.39	0.39	0.40	0.42
Copper, ppm	23.8	23.1	23.6	24.7
Iron, ppm	135.4	117.8	103.9	103.4
Manganese, ppm	49.6	42.4	36.6	38.6
Selenium, ppm	0.18	0.17	0.15	0.15
Zinc, ppm	66.9	66.1	68.4	71.3

[a]Except for premixes and supplements, crude protein of ingredients was analyzed using AOAC (1996) procedures; remaining diet composition was calculated from ingredient analysis based on NRC (1984) values.

Table 2. Ingredient and nutrient content of feedlot supplement, (DM basis)

Item	%
Ingredient compostion	
Soybean meal, 47.7% CP	57.44
Wheat middlings	11.55
Limestone	10.35
Urea	8.85
Dicalcium Phosphate	3.70
Plain mixing salt	2.65
Potassium Chloride	4.70
Rumensin 80[a]	.225
Tylan 40[b]	.150
Vitamin A-30,000[c]	.125
Magnesium oxide	.031
Zinc sulfate	.150
Copper Sulfate	.078
Vitamin E-50[d]	.012
Cobalt Carbonate	.0008
Calculated nutrient composition	
Crude protein, %	58.90
NE_m, Mcal/kg	13.89
NE_g, Mcal/kg	9.39
Fat, %	1.10
Crude fiber, %	3.00
Potassium, %	3.99
Calcium, %	5.42
Phosphorus, %	1.28
Magnesium, %	0.28
Sulfur, %	0.35
Cobalt, ppm	3.99
Copper, ppm	228.00
Iron, ppm	746.00
Manganese, ppm	284.00
Selenium, ppm	0.08
Zinc, ppm	630.00

[a]Rumensin 80 was added in this amount to achieve 35.7 mg/kg of the active ingredient Monensin in the final diet.

[b]Tylan 40 was added in this amount to achieve 11.5 mg/kg of the active ingredient Tylosin in the final diet.

[c]Vitamin A: concentration 13,607.9 IU/kg was added to achieve 690.8 IU/kg in the final diet.

[d]Vitamin E-50 was added to achieve 1.16 IU/kg in final diet.

Table 3. Bunk scoring system used to estimate feed remaining in feed bunk at the time bunks were evaluated

Bunk Score	Amount of Feed
0	Bunk slick
1	Less than .45 kg
2	.45 – 2.3 kg
3	2.3 – 4.5 kg
4	4.5 – 6.8 kg
5	Greater than 6.8 kg

Table 4. Least square means for weights and performance of steers that grazed Old World bluestem in 1999 and 2000

	Treatments^a				
	IES	HIES	SL	SLS	SE^b
Weight, kg					
Initial^c	239	234	235	238	2.65
Mid^d	273^j	291^k	294^k	299^k	4.25
Final^e			331^j	344^k	3.17
Gain/steer, kg					
Early^f	33.5^j	57.3^k	58.7^k	61.6^k	2.15
Late^g			37.3^j	45.0^k	1.60
Total^h			96.0^j	106.5^k	2.53
ADG, kg/d					
Early^f	0.51^j	0.87^k	0.89^k	0.93^k	0.03
Late^g			0.55^j	0.66^k	0.02
Total^h			0.71^j	0.79^k	0.02
Gain/ha, kg/ha					
Early^{fi}					
1999	115.0^x	132.5^{xy}	150.7^{yz}	167.4^z	12.66
2000	258.0^j	201.2^k	186.5^k	189.2^k	12.66
Late^g			106.5^j	129.9^k	4.73
Total^h			275.1^j	308.2^k	8.78

^{a}Treatments: IES - intensive early stocking; HIES - half intensive early stocking; SL - season long grazing; SLS - season long grazed and supplemented with 0.18 kg·steer^{-1}·d^{-1} of CP in the late summer.

^{b}Standard error of the means.

^{c}Initial weights taken on May 12 - Year 1 and 2

^{d}Mid weights taken on July 20 - IES and HIES and July 21 - SL and SLS in Year 1; July 17 - IES and HIES and July 18 - SL and SLS in Year 2.

^{e}Final Weights taken on September 28 – Year 1; September 25 – Year 2.

^{f}Early grazing season for Year 1: IES and HIES = 68d, SL and SLS = 69d; Year 2: IES and HIES = 65d, SL and SLS = 66d

^{g}Late grazing season for Year 1 and 2: 68d

^{h}Total grazing season for Year 1: 137d; Year 2: 134d

^{i}Treatment x year interaction ($P < 0.05$)

^{j,k,l}Means within a row without common superscripts differ ($P < 0.05$)

^{x,y,z}Means within a row without common superscripts differ ($P < 0.10$)

Table 5. Residual forage mass (kg/ha) of Old World bluestem in 1999 and 2000 (DM basis)

	1999	2000
IES[a]		
Forage mass, kg/ha		
May[b]	2017	1793
July[c]	1267	1835
Sept[d]	4695	
HIES[a]		
Forage mass, kg/ha		
May[b]	2401	2002
July[c]	3784	5285
Sept[d]	6686	
SL[a]		
Forage mass, kg/ha		
May[b]	1799	2032
July[c]	3180	5632
Sept[d]	3203	5286
SLS[a]		
Forage mass, kg/ha		
May[b]	1944	1955
July[c]	3021	7150
Sept[d]	3016	5235

[a]Treatments: IES – Intensive early stocking; HIES – Half intensive early stocking; SL – Season long grazing; SLS – Season long grazed and supplemented with 0.18 $kg \cdot steer^{-1} \cdot d^{-1}$ of CP in the late summer.

[b]Samples were clipped on May 28, 1999 and on May 17, 2000.

[c]Samples were clipped on July 29, 1999 and July 17 and 18, 2000.

[d]Samples were clipped on September 28 and 30, 1999 and September 28, 2000

Table 6. Nutritive value of Old World bluestem in 1999 and 2000

	1999[a]			2000[b]	
	Date			Date	
	May 28	July 29	Sept 28 & 30	June 13 & 14	August 17 & 18
IES[c]					
OM[d], % DM	93.9	92.9	93.7	88.5	
CP[e], %OM	17.2	16.4	10.4	16.2	
DIP[f], %OM	54.1	49.9	55.6	58.3	
IVOMD[g]	87.4	88.8	77.9	75.8	
HIES[c]					
OM[d], % DM	93.7	92.9	94.6	90.3	
CP[e], %OM	19.0	13.4	10.8	14.7	
DIP[f], %OM	56.7	48.1	57.8	55.2	
IVOMD[g]	86.8	88.2	73.2	82.3	
SL[c]					
OM[d], % DM	93.6	93.8	93.8		89.7
CP[e], %OM	19.4	10.7	10.9		12.0
DIP[f], %OM	57.9	46.5	57.3		57.1
IVOMD[g]	86.1	85.4	70.7		72.5
SLS[c]					
OM[d], % DM	93.8	93.9	94.1		91.1
CP[e], %OM	18.1	11.0	10.8		11.3
DIP[f], %OM	54.4	45.3	63.0		53.4
IVOMD[g]	85.9	79.6	71.5		67.6

[a]Diet samples were collected by hand plucking in 1999 to try and mimic animal diets at or near the time cattle weights were taken.

[b]Diet samples were collected in 2000 with ruminally cannulated animals during the early and late grazing seasons to attain an estimation of forage quality during that growing season.

[c]Treatments: IES – Intensive early stocking; HIES – Half intensive early stocking; SL – Season long grazing; SLS – Season long grazed and supplemented with 0.18 $kg \cdot steer^{-1} \cdot d^{-1}$ of CP in the late summer.

[d]OM – Organic matter percent equals residual ash subtracted from 100 and multiplied by 100.

[e]CP – Crude protein equals the percent N multiplied by 6.25.

[f]DIP – Degradable intake protein equals undegradable intake protein subtracted from 100.

[g]IVOMD – Invitro organic matter digestibility was not corrected to a known standard.

Table 7. Feedlot performance of steers that previously grazed Old World bluestem

	Treatments[a]				
	IES	HIES	SL	SLS	SE[b]
Steers/treatment	30	30	25	30	
Days on Feed	173	173	139	139	
Weight, kg					
Initial[c]	297^{e}	309^{f}	361^{g}	373^{h}	18.6
Final[d]	525	528	548	537	37.6
Total gain/steer, kg	228^{e}	218^{e}	186^{f}	164^{g}	6.5
ADG, kg/d	1.32	1.26	1.34	1.18	.04
Total DMI/steer, kg	1697^{e}	1619^{e}	1461^{f}	1409^{f}	28.8
DMI·steer^{-1}·d^{-1}, kg	9.8^{eg}	9.4^{e}	10.5^{f}	10.1^{fg}	.2
Gain/feed	$.135^{e}$	$.135^{e}$	$.128^{e}$	$.116^{f}$	.004

[a]Least square means for each treatments. Treatments: IES – Intensive early stocking; HIES – Half intensive early stocking; SL – Season long grazing; SLS - season long grazed and supplemented with 0.18 kg·steer^{-1}·d^{-1} of CP in the late summer.

[b]Standard error of the least square means.

[c]Initial weights: IES and HIES taken July 17,2000; SL and SLS taken September 25, 2000.

[d]Final weights: IES and HIES taken January 8, 2001; SL and SLS taken February 13, 2001.

[e,f,g,h]Means within row with different superscripts differ ($P < 0.05$).

Table 8. Carcass characteristics of steers that previously grazed Old World bluestem

	Treatments[a]				
	IES	HIES	SL	SLS	SE[b]
No. of steers	30	30	25	29	
Carcass weight, kg	328	330	342	336	4.66
Ribeye area, cm^2	83.51	83.31	86.45	87.11	1.35
KPH fat, %	1.62[h]	1.78[i]	1.98[j]	2.08[j]	.06
Fat thickness, cm	1.13	1.16	1.19	1.27	.08
Yield Grade	2.54	2.63	2.65	2.65	.12
Yield grade dist.					
Yield Grade 1, %	20.0	10.0	20.0	17.2	
Yield Grade 2, %	60.0	66.7	48.0	55.2	
Yield Grade 3, %	20.0	23.3	32.0	27.6	
Marbling score[c]	402.0	409.7	404.8	399.0	12.6
Premium Choice, %[d]	10.0	13.3	4.0	0.0	
Low Choice, %[e]	30.0	30.0	52.0	62.1	
High Select, %[f]	40.0	30.0	32.0	31.0	
Low Select, %[g]	20.0	26.7	12.0	6.9	

[a]Least square means for each treatment; Treatments: IES – Intensive early stocking; HIES – Half intensive early stocking; SL – Season long grazing; SLS - season long grazed and supplemented with 0.18 $kg \cdot steer^{-1} \cdot d^{-1}$ of CP in the late summer.

[b]Standard error of the least square means.

[c]Marbling score: 400 to 499 = "Small" degree, the minimum U.S. Choice; 300 to 399 = "Select" degree.

[d]Carcasses with Modest or Moderate degree of marbling (Upper 2/3 Choice).

[e]Carcasses with small degree of marbling.

[f]Carcasses with Slight degree of marbling and marbling score: 350 to 399.

[g]Carcasses with Slight degree of marbling and marbling score: 300 to 349.

[h,i,j]Means within row with different superscripts differ ($P < 0.05$).

Table 9. Percent choice carcasses from steers grazed early or season long on Old World bluestem

	Treatments[a]	
	Early[b]	Late[c]
No. of steers	60	54
Choice, %[d]	41.7[f]	58.3[g]
Select, %[e]	59.3[f]	40.7[g]

[a]Percents for each treatment.
[b]Early: Intensive early and Half intensive early stocked steers.
[c]Late: Season long and Season long supplemented steers.
[d] Carcasses with Small degree of marbling or greater.
[e]Carcasses with Slight degree of marbling or less.
[f,g]Percents within row with different superscripts differ ($P < 0.10$)

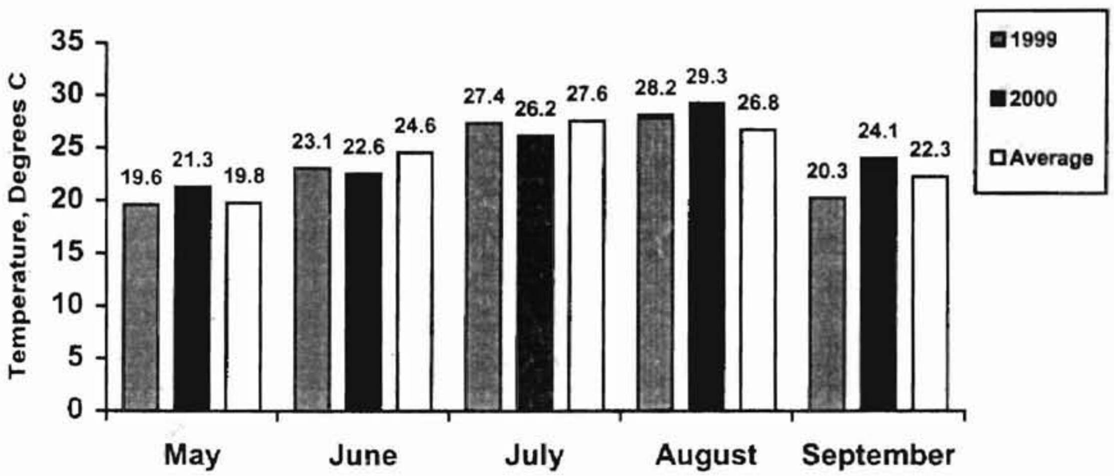

Figure 1. Average temperatures during the months of May, June, July, August, and September recorded by the Marena station of the Oklahoma mesonet system, and the ten-year average for Payne county Oklahoma.

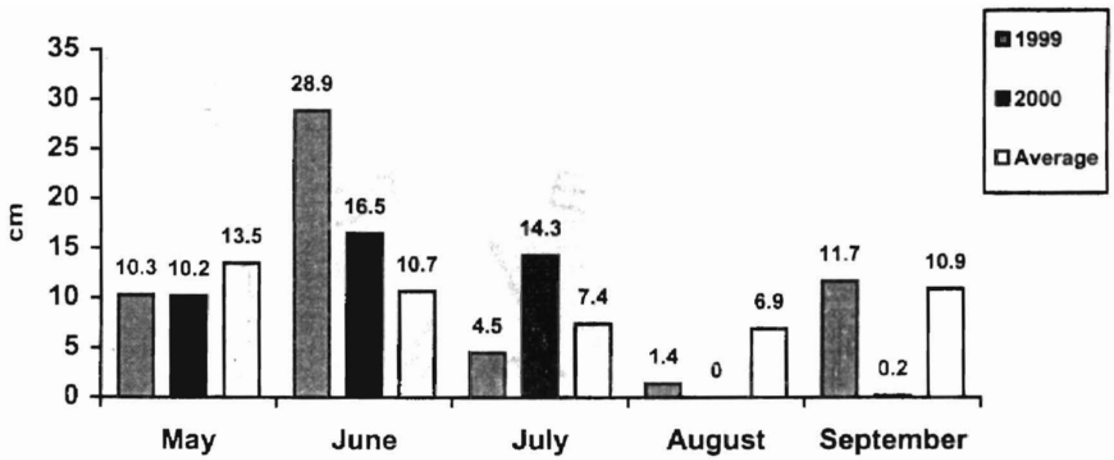

Figure 2. Average precipitation during the months of May, June, July, August, and September recorded by the Marena station of the Oklahoma mesonet system, and the ten-year average for Payne county Oklahoma.

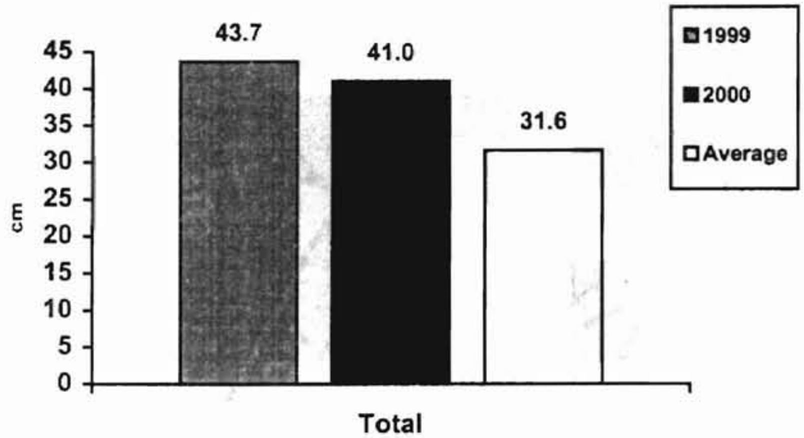

Figure 3. Total precipitation for May, June, and July recorded by the Marena station of the Oklahoma mesonet system, and the ten-year average for Payne county Oklahoma.

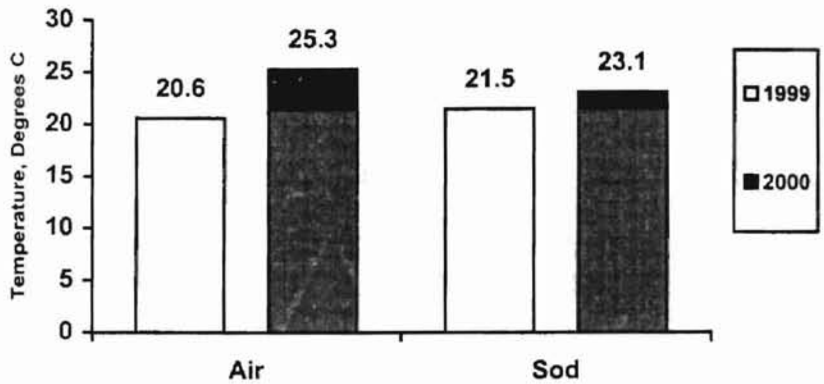

Figure 4. Average air and sod temperatures for the last nine days of May recorded by the Marena station of the Oklahoma mesonet system.

VITA

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Candidate for the Degree of

Master of Science

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