EVALUATION OF BY-PRODUCT FEEDSTUFFS, LEVEL OF CONCENTRATES, AND SELENIUM AND VITAMIN E INJECTIONS ON PERFORMANCE AND HEALTH OF BEEF CALVES IN BACKGROUNDING SYSTEMS

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(ABSTRACT)

Weaning stress in young calves is often compounded with stress from transport, marketing, and commingling. The result is a weakened immune system, which can lead to increased incidence of diseases, especially bovine respiratory disease complex (BRDC). Backgrounding cattle post-weaning and prior to feedlot entry may alleviate some of the more common stresses and typically diminished feed intake. Five trials were conducted with a total of 228 weaned calves to evaluate different backgrounding systems. Drylot diets with 70:30 and 40:60 forage to concentrate total mixed rations with Se and vitamin E injections were studied. No differences were observed in daily gains or feed efficiency among treatments. Steers receiving Se injections had higher ($P < 0.05$) blood Se concentrations on d 7, 14, 28, and 42. Steers grazed four types of stockpiled pastures with previous pasture treatments: control, poultry litter fed to previous grazing cattle, poultry litter applied, and inorganic fertilizer. Supplements (16% CP) for each pasture treatment were none, soy hulls + SBM (0.5% BW), and corn + SBM (0.5% BW). On d 7, unsupplemented steers had higher ($P < 0.05$) daily gains than steers supplemented with corn + SBM. No differences were detected on any other day. Heifers grazed stockpiled fescue and were fed three 16% CP supplements: corn gluten feed + soy hulls

(0.5% BW), corn gluten feed + soy hulls (1.0% BW), and soy hulls + SBM (0.5% BW). On d 14, heifers supplemented with soy hulls + SBM had higher ($P < 0.05$) cumulative daily gains. No other differences were detected in gains among treatments. Steers were allotted to four injection treatments: none, Se, vitamin E, and combination of Se and vitamin E. There were no differences in daily gain or blood Se concentrations on any day among all treatments. Steers grazed two pasture types: fescue and fescue + alfalfa, with the following injections: none, vitamin E, and Se. There were no differences in daily gains among all treatments. On d 7, 14, 28, and 42, steers receiving Se injections had higher ($P < 0.05$) blood Se concentrations. On d 7 and 14, steers grazing fescue pastures had higher serum alpha-tocopherol concentrations than steers grazing fescue + alfalfa pastures. There were no differences in serum alpha-tocopherol concentrations due to injection treatment on any day. No consistent differences were detected in forage and blood serum mineral concentrations in all trials. There were no differences in gains from by-product supplementation versus “traditional” corn-based supplementation, suggesting that by-product feedstuffs may be of value for backgrounding rations. Selenium and vitamin E supplementation did not have any significant effect on calf morbidity.

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TABLE OF CONTENTS

Backgrounding Trials with Calves

    Animals and Diets

  RESULTS

    Drylot Study

Pasture Study 1 – Nutrient Management

Pasture Study 2 – Heifer Development

Pasture Study 3 – Big Meadow

Pasture Study 4 – Kentland

LIST OF TABLES

LIST OF FIGURES

Introduction

Backgrounding is a common term referring to the transitional time period between weaning and entering the feedlot or stockering. The process of backgrounding utilizes strategies to alleviate weaning stress and prepare cattle for the next stage of production. Weaning is one of the most stressful time in the lives of beef cattle. Separation from the cows, new surroundings, and unfamiliar feeds can cause significant stress on young calves. A backgrounding system includes components such as familiarizing the animals to feed bunks and automatic waterers, conditioning calves to consuming prepared feed, and maintaining a healthy immune system with proper vaccination and vitamin and mineral supplementation.

Research from USDA-APHIS (1994) reported death losses of 1.5 to 2.7% in feedlot cattle. Nearly 70% of the deaths were caused by respiratory infections associated with bovine respiratory disease complex (BRDC). Bovine respiratory disease costs the beef industry $600-700 million annually (Loan, 1984). Newly weaned calves are most susceptible to these diseases. As a result of stress from weaning, marketing and transport, and commingling with cattle from other locations, animals may become sick and require medical treatment and at an additional expense, may experience a period of suppressed weight gain. Proper backgrounding of newly weaned cattle may help to enhance their ability to quickly recover from weaning and shipping stresses and begin functioning normally again.

Backgrounding systems may be established in either a pasture or a drylot settting, Pasture-based systems may or may not incorporate additional supplementation. Supplements and diets for backgrounding usually consist of relatively easily digestible feeds that are palatable to a young animal and meet or exceed their nutritional requirements. It may be possible to utilize by-product feeds in lieu of more expensive traditional feeds and obtain comparable results in terms of animal performance. Appropriate vitamin and mineral supplementation is also important in backgrounding programs.

The objectives of the present study were to evaluate several different backgrounding systems on the effects of performance and health on newly weaned beef calves.

Literature Review

Stress

Stress in beef cattle may result from many sources. Calves are exposed to stress from weaning, new surroundings, new feeds, unfamiliar territory, human handling, marketing and shipping, vaccination, and the introduction of other animals (Hutcheson and Cole, 1986; Sconberg et. al., 1993; Grandin, 1997; Church and Hudson, 1999; Fluharty and Loerch, 2000; Dixit et al., 2001; Price et. al, 2003). Stress can result in decreased feed intake, a suppressed immune system, nutrient loss from the body, and potential sickness (Lofgreen, 1983; McEwen et al., 1997; Briggs et al., 1998; Frank et al., 2002). Type and timing of weaning can have direct effects on calf health and performance. Price et al. (2003) observed the responses of calves to fenceline contact with their dams at weaning in an effort to reduce negative separation effects on behavior and growth rate. One hundred Angus/Hereford cross calves were randomly assigned to five weaning regimes: a control group of non-weaned calves on pasture, fenceline separation from dams on pasture, total separation from dams on pasture, total separation from dams and fed hay in drylot with preconditioning to hay, and total separation from dams and fed hay in drylot without preconditioning to hay. Calves in treatment groups were observed for 7 d and then grouped back together on pasture. During the 7 d treatment period, calves sharing a fenceline with their dams and the non-weaned controls spent significantly more time grazing and laying down than the calves on the other treatments. Ten weeks after weaning, calves sharing a fenceline with their dams had gained 50 kg compared to 41.4, 36.1, and 37.2 kg gained by pasture separated, drylot separated (preconditioned to hay), and drylot separated (not preconditioned to hay) calves, respectively. The non-weaned controls gained 64.8 kg. The weights of calves separated by the fenceline from their dams were not different from the non-weaned controls. The researchers concluded that fenceline contact with cows for 7 d following weaning reduced behavioral stress when compared with totally separated counterparts. The fenceline contact also minimized weight loss in the days immediately following weaning.

Church and Hudson (1999) investigated the effects of abrupt and interval weaning on wapiti calves. Thirty-four wapiti calves were randomly assigned to either an abrupt or interval weaning program. Both groups of calves were weaned at the same age. The abrupt weaned group was separated from their dams into a large pen, then moved to a large pasture out of sight and hearing from the dams (approximately 1 km away). The interval weaned group were weaned over a period of 10 d, during which time a few dams per day were moved to an adjacent pasture, and then to a remote pasture, as with the abrupt weaned group. Behavior of both groups of calves was monitored and recorded. The abrupt weaned group spent significantly more time vocalizing and pacing the fencelines than the interval weaned calves. Baseline and periodic measurements of lymphocyte activity were taken. The abrupt weaned group had higher neutrophil to lymphocyte ratios, suggesting a higher degree of stress. Immune suppression in calves is associated with an increase in concentration of glucocorticoids in response to stress (McEwen et al., 1997).

Dixit et al. (2001) investigated the effect of transport stress on adrenocorticotropin secretions from lymphocyte cells. Twelve Holstein cows were catheterized with indwelling jugular catheters and transported for 14 h over typical highway conditions. After transport, six cows were unloaded, fed, watered, and rested in stalls for 24 h. The remaining six cows were fed, watered, and rested inside the truck for 24 h. Blood samples were taken prior to transport, immediately post-transport, and at the conclusion of the 24 h rest period. Adrenocorticotropin concentrations in the lymphocyte cells increased in both groups of cows from pre-transport to immediately post-transport. However, by 24 h post-transport lymphocytic adrenocorticotropin concentrations in the cows unloaded and rested in stalls had returned to near baseline, while the adrenocorticoptropin concentrations in the cows not unloaded remained elevated.

Sconberg et al. (1993) investigated the effects of shipping, handling, adrenocorticotropin hormone (ACTH) and epinepherine on ? -tocopherol concentrations in calves. They also analyzed plasma samples for creatine kinase (CK) concentrations in order to estimate the extent of muscle tissue damage caused by stress. During stress, the autonomic nervous system responds by releasing norepinepherine and stimulating the adrenal glands to release both epinepherine and norepinepherine. Fifteen steers weighing approximately 319 kg, were fed 1000 IU vitamin E · hd^{-1} · d^{-1} for 28 d. Blood samples were taken at the beginning and the end of the 28 d trial as well as every 2 wk during the feeding period. Analysis for plasma tocopherol indicated a drop in tocopherol concentrations at 1 wk following arrival at the feedlot and a gradual increase in concentrations by wk 3. The steers supplemented with 1000 IU vitamin E · hd^{-1} · d^{-1} had higher than normal CK concentrations during wk 1. The trial was designed as an observational study and did not use control animals. Data were compared to normal book value averages of CK and ? -tocopherol concentrations. A second study simulated stress by injecting ACTH and epinepherine to heifers with adequate vitamin E status. Five heifers served as non-stressed controls and five heifers received the stress-simulating injections. Blood samples were taken on d 1, 2, 3, 6, 9, and 10 to determine the effects of repeated handling. In stressed heifers, after 9 d plasma tocopherol concentrations significantly decreased to baseline d 1 values. The heifers with adequate vitamin E status that were treated with ACTH or epinepherine had increased CK concentrations, but showed no outward signs of stress and ate normally. A third study consisted of 10 Holstein heifers, weighing approximately 298 kg. The heifers were fed a vitamin E deficient diet. Five heifers served as non-stressed controls and five received stress-simulating injections as mentioned earlier. Plasma tocopherol concentrations were not affected by ACTH or epinepherine injections. All heifers had increased CK concentrations, regardless of injection treatment. Sconberg et al. concluded that vitamin E should be supplemented to reduce muscle damage caused by stress.

Grandin (1997) suggested that 200 to 300 kg calves shipped from the Southeast to feedlots in Texas would have fewer health problems if shipped the entire distance (approximately 32 h) without rest stops. Grandin's reasoning is based on the hypothesis that the effects of psychological stress or trauma during unloading combined with potential disease exposure. Several options exist to counteract the effects of marketing and transport stress.

Lofgreen et al. (1983) studied the effectiveness of mass medication in reducing shipping fever and BRD in stressed calves. Treatments were three successive days of i.m. injections of long acting oxytetracycline (LAOTC) (1.75 g/hd), oral administration of a bolus containing 25 g sustained release sulfadimethoxine, or no medication. They concluded that LAOTC reduced the number of medical treatment days per calf by 21% and that the sulfadimethoxine bolus reduced the number of medical treatment days per calf by 20%.

Briggs et al. (1998) studied the spread of *Pasteurella haemolytica* among transported calves. One-hundred-four Angus and Angus crossbred calves were purchased from a single farm. Tonsil and nasal specimens were collected 15 wk and 1 wk prior to shipping, and 0, 1, and 4 wk after arrival at the feedlot. Twenty-seven additional calves were introduced to the original 104 at the order barn after tonsil and nasal specimens were gathered. One-half of the calves were vaccinated at the farm and again at the order barn with killed *P. haemolytica*. Before transport to the feedlot, six vaccinated and six control calves were innoculated with *P.*

haemolytica NADC-D36. These innoculated calves were allowed to commingle with the non-innoculated calves. At the feedlot, calves were kept in pens allowing nose-to-nose contact and shared waterer contact. Nasal and tonsil swabs were collected at wk 0, 1, and 4 after arrival at the feedlot, and *P. haemolytica* was isolated in the samples. The normal nasal flora of calves includes colonies of *P. haemolytica* serotype 2 (ST2). Stress or viral infection causes proliferation of *P. haemolytica* serotype 1 (ST1). Of the original 104 calves, seven were culture-positive for *P. haemolytica* ST1. Of the 27 calves commingled at the order barn, 13 were culture-positive for *P. haemolytica* ST1. Over the 4 wk post-transport period at the feedlot, 60 of the calves tested culture-positive on one or more sampling dates for *P. haemolytica* ST1. The researchers concluded that *P. haemolytica* ST1 was being spread horizontally between animals, through the active shedding of the *P. haemolytica* ST1 at the order barn.

Angen et al. (1999) used rRNA sequencing and DNA-DNA hybridization to propose reclassification of *P. haemolytica* into the genus *Mannheimia*. The proposal was accepted, and subsequent studies refer to *P. haemolytica* as *M. haemolytica*.

Frank et al. (2002) investigated the effects of vaccinations prior to shipping and upon arrival at the feedlot on the health of transported calves by determining *Mannheimia haemolytica* (MH) in nasal secretions. Two-hundred-five steers were transported to a feedlot in New Mexico. Prior to loading on the truck, every other steer through the chute was vaccinated with a MH toxoid. Upon arrival at the NM feedlot, 60 steers (30 vaccinated and 30 non-vaccinated steers) were injected with 40 mg/kg florfenicol in the neck. Most respiratory tract diseases occurred and were treated within wk 1 at the feedlot. The number of treatments for steers with respiratory tract diseases was significantly higher for non-medicated animals compared to medicated animals. Vaccination with MH bacterin-toxoid did not affect the number of steers treated for respiratory tract diseases or the concentrations of MH in the nasal passages.

Hutcheson and Cole (1986) discussed the management of transit-stress syndrome and its nutritional and environmental effects on cattle. They noted the difficulty in formulating diets to meet nutritional requirements when animals were not consuming feed at a minimum of 1.5% BW. They also recognized that environmental factors, such as new automatic waterers, feeders, or unfamiliar pastures have a greater detrimental effect on morbid calves than on healthy calves.

Loerch and Fluharty (2000) hypothesized that using trainer animals may help alleviate some of the stress associated with new feedlot arrivals. Trainer animals consisted of mature cull cows and steers previously accustomed to the feedlot environment. The trainer animals arrived at the feedlot 3 wk prior to the start of the experiment to adjust to conditions. One-hundred-eighty weaned calves were transported from 65 to 830 km to the feedlot. Upon arrival, calves were vaccinated against IBR, PI_3, 7-way clostridium bacterin, *Haemophilus somnus*, and pasteurella. The calves were then randomly assigned to pens of 9 or 10 animals with either a trainer cow, trainer steer, or no trainer animal. There were six pens in each treatment. Trainer animals remained with their respective pens of calves for the first 14 d of the 28 d feeding trial. During wk 1 of the trial, calves with trainer animals (cows or steers) gained 60% more weight than calves without trainer animals. However, during wk 2, calves without trainer animals gained significantly more weight. Final weights did not differ among groups. Morbidity was 16.7, 28.3, and 8.3% for control calves, calves with trainer steers, and calves with trainer cows, respectively. On d 1 a greater percentage of calves in trainer cow groups were seen eating at the bunks (81.7%) than calves with trainer steers (60%) or control calves (48.3%). Although the trainer animals were not in contact with the calves for a long period of time, the researchers concluded that the introductory social grouping may be an effective method to alleviate some stress and help newly arrived feedlot calves adjust to the new environment.

Wahlberg, et al. (1998) backgrounded newly weaned calves on three different treatments to determine the economic and health benefits to the cattle. Calves were randomly allotted to three treatments: pasture only, pasture + 14.9% CP corn + SBM supplement, or hay (barn-housed) and 14.9% CP corn + SBM supplement. Steers fed the hay + grain treatment (barn-housed) had the highest ADG (2.60 lb/d). Gains were lowest for the pasture-only treatment (1.55 lb/d). No animals in any of the treatments required medical attention. All three treatments, regardless of ADG or final weight, would increase profit to producers.

Protein

The NRC (2000) CP requirement for stressed calves is 12.5 to 14.5 %, DM basis. Eck et al. (1988) studied the effects of protein source and level on incoming feeder cattle. The three protein supplements in the 28 d study were: urea, cottonseed meal, and a 50:50 combination of blood meal and corn gluten meal. Calves were also fed grass hay. The diets were formulated to contain CP levels of 10.5 and 12.5%, using steam flaked sorghum and the respective protein source. Cattle consuming the blood meal-corn gluten meal mix had greater ADG than any other treatment. Both ADG and feed efficiency were greater for cattle consuming the 12.5% CP diet versus the 10.5% CP diet.

In 1990, Cole and Hutcheson fed diets containing either 12 or 16% CP to 84 steers and recorded morbidity and performance data. There were no differences in morbidity or mortality, but animals consuming the higher protein diet tended to have fewer relapses and fewer medical treatments per calf. Calves fed the 16% CP diet had greater ADG ($P < 0.05$) and tended to have greater ($P = 0.1$) DMI and feed efficiency in the first 14 d of the trial.

Fluharty and Loerch (1995) conducted a 42-d trial to determine the effects of a high concentration of CP and various protein sources in the receiving diet of feedlot cattle. The levels of protein were 12, 14, 16, or 18% CP, DM basis, and protein sources were either soybean meal or spray dried blood meal (SDBM). During the first week of the trial, feeding the 16 or 18% CP diets resulted in a 14.3% increase in DMI. There was a linear increase in ADG and feed efficiency with increasing CP concentration over the course of the trial. There were no differences in steer performance due to protein source. They concluded that the protein requirements for stressed versus non-stressed calves may not necessarily be different in terms of grams of protein required. Instead, Fluharty and Loerch concluded that attention must be given to how much feed the animal is actually consuming and consequently, what quantity of protein is being digested.

Austin (2001) conducted several 42-d trials to determine the benefits of feeding a 15% CP supplement at various quantities. The results indicated that feeding 15% CP at 0.5% BW produced higher ADG at d 28 than feeding 15% CP at 1.0% BW. Animals supplemented at 0.5% BW required less feed per unit of gain than animals fed 15% CP at 1.0% BW by d 42. Both supplementations increased ADG ($P < 0.05$) , but had no effect on animal health, compared to a control group of animals receiving no supplementation. Studies at Virginia Polytechnic Institute and State University showed that supplementation of 15% CP at 0.5% BW compared to no supplementation had no effect on ADG and final weight of grazing steers (Fontenot, J. P, and K. H. Hutchinson, unpublished).

Energy

The 2000 NRC energy requirement for stressed cattle (Ne_m, Mcal/kg) is 1.3 to 1.6 Mcal/kg DMI. Extensive work has been conducted in terms of energy levels in starting diets for calves. Lofgreen et al. (1963) conducted a number of trials investigating varying energy levels. When fed 20, 55, or 72% concentrate diets, calves consuming the higher energy feed gained more than calves consuming a lower concentrate feed. Over 28 d, there were no significant differences in animal performance between the cattle consuming the 55 and 72% concentrate. A second experiment had three treatments: 55% concentrate, 72% concentrate, or self-selcetion among diets containing 20, 55, 72, or 90% concentrate. During wk 1, the self-selection group did not gain as well as groups fed either 55 or 72% concentrate diets. Diets lower in energy resulted in slower and more expensive gains over the course of the entire 28 d feeding period. Lofgreen et al. (1981) found that animals fed a high-concentrate diet (72%) consumed less feed than those fed a lower-concentrate diet (55%), and had greater feed efficiencies. The results of Fluharty et al. (1994) and Fluharty and Loerch (1996) agree with these results.

Chase and Hibberd (1989), evaluated corn-based supplementation with two different feeding frequencies: every day or every other day. Ruminal pH was lower on the day of supplementation, but higher on the next day for the alternate day treatments. Ruminal ammonia for all treatments was low, and attributed by the researchers to the decreased digestion when supplement was fed.

Kunkle et al. (1999) discussed designing supplementation programs for beef cattle fed forage-based diets. When determining supplements for cattle being fed forage, nutritional requirements must be taken into account. This includes energy, mineral, and protein requirements. Concentrates can be fed up to 0.5% BW without significantly decreasing forage intake. However, advantages have been observed when feeding soy hulls at levels higher than 0.5% BW (Garces-Yepez et al., 1997).

Mulligan et al. (2002) studied the effects of digestibility and forage to concentrate ratios on the performance and ruminal characteristics of steers. The 2x2 factorial included two levels of supplementation (maintenance and 1.6 X maintenance), and two grass silage to soy hulls ratios (50:50 and 15:85). Increasing the feeding level and the proportion of soy hulls reduced DM, CP, NDF, and ADF digestibility. Increasing feeding level from maintenance to 1.6 X maintenance reduced rumen pH at 2, 4, and 6 h post-feeding.

Minerals

When cattle are consuming below optimum quantities of feed, mineral deficiencies may result. Increased mobilization and excretion of some minerals is also more likely to occur in stressed animals (Galyean, et. al, 1999). While the dietary requirement of chromium for cattle is widely debated, it has been hypothesized that feedlot calves undergoing weaning, marketing, and feedlot stress are Cr deficient, even though Cr deficiencies are uncommon in most production systems (Burton, 1995). Several studies have been conducted to evaluate the benefits of Cr supplementation for stressed calves (Chang and Mowatt, 1992; Moonsie-Shageer and Mowatt, 1993; Kegley and Spears, 1995). Chromium is a component of glucose-tolerant factor (GTF) that potentiates insulin action (Mertz, 1969; Mertz, 1993). The potential insulin action may lead to increased growth and feed efficiency by improving glucose utilization.

Chang and Mowatt (1992) and Moonsie-Shageer and Mowatt (1993) studied the effect of supplemental Cr for stressed and growing feeder calves. Feeding 0.1 to 1 ppm Cr increased ADG of calves in both experiments during the first 2 wk ($P < 0.05$), after which there were no differences between supplemented groups and non-supplemented groups. The researchers concluded that Cr supplementation just before shipping and marketing stress or in the receiving diets of stressed or growing calves would be most beneficial.

Kegley and Spears (1995) determined that supplemental Cr from high-Cr yeast and Cr-nicotinic acid complex did not improve animal performance, but improved serum immunoglobulin G (IgG) titers. Kegley et al. (1997) conducted another experiment with supplemental Cr, and determined that it did not affect immune response, but did improve ADG regardless of whether or not cattle were subjected to shipping stress.

Because inorganic forms of Cr are unavailable for absorption, Swanson et al. (2000) investigated the benefits of supplementing high-Cr yeast to growing beef steers. Twenty-four steers were purchased and innoculated for infectious bovine rhinotracheitis (IBR) and parainfluenza 3 virus (PI3), and fed grass hay ad libitum for 30 d until they had adjusted to their new environment and all outbreaks of respiratory disease had passed. Steers were randomly assigned to four Cr treatments: 0, 100, 200 or 400 ug Cr from Cr-yeast/kg DM diet. Indwelling jugular catheters were placed in each steer to measure response to intravenous glucose tolerance tests and intravenous insulin challenge tests. Chromium supplementation had no effect on steer ADG, BW, gain efficiency, glucose half-life or glucose clearance rate. Swanson, et al. concluded that while supplementation with high-Cr yeast had no effect on performance measures, the results may have been attributed to the pre-existing Cr status of the steers. If adequate, then additional Cr supplementation would not have elicited any effects.

Orr et al. (1990) studied mineral alterations during bovine respiratory disease (BRD) and after an infectious bovine rhinotracheitis (IBR) inoculation of healthy calves. Copper, Zn, P, and Ca concentrations were monitored in the bloodstream. Nine days after BRD, serum Cu increased ($P < 0.05$) and serum Zn concentrations were lower in infected animals than healthy animals. Four days after inoculation with IBR, serum Zn concentrations were reduced ($P < 0.05$) and serum Cu was increased ($P < 0.05$) 1 d after inoculation with IBR. Serum Ca was increased ($P < 0.05$) on d 4 following inoculation and serum P was decreased. Orr et al. concluded that a decreased feed intake and the IBR inoculation decreased the serum Zn concentrations, and that the increases in Cu and Ca were due to shipping and transit stress and not to the BRD infection.

Selenium and vitamin E

Since the mid 1950s, Se has been recognized as an essential dietary component. Selenium deficiency is manifested most notably in white muscle disease (WMD) (McDowell, et al., 1996). Young animals may be stillborn or die within a few days of birth, or survive but remain unthrifty. Selenium plays a role in the formation of the enzyme, glutathione peroxidase (GSH-Px), which acts to convert harmful peroxides in the cells to less harmful alcohols (Berdanier, 1998). Selenium is transferred across the placenta efficiently, but less efficient via colostral transfer (Koller, et al., 1984). Vitamin E is a lipid soluble antioxidant (Olson, 1984). Vitamin E molecules scavenge reactive oxygen species and lipid hydroperoxides. The enzyme, GSH-Px acts in the cytosol and phospholipid layer of the cell while vitamin E functions in the lipid membrane layer (Putnam and Comben, 1987; Weitzel et al., 1990). The NRC (2000) recommends 15 to 60 international units (IU) of vitamin E per kg diet for young calves. The Food and Drug Administration (FDA) allows a maximum of 3 mg $\text{Se} \cdot \text{hd}^{-1} \cdot \text{d}^{-1}$ or 0.3 mg Se/kg mixed in the feed. The NRC (2000) Se requirement for growing cattle is 0.1 mg/kg. Both vitamin E and Se play active roles in immune function (Berdanier, 1998). Swecker et al. (1995) determined that supplementing cows with Se enhanced IgG concentrations or increased the IgG transfer from serum to colostrum.

Droke and Loerch (1989) conducted a study to determine the effects of vitamin E and Se on performance, health, and humoral immune responses of steers new to the feedlot environment. Supplementation with Se, vitamin E, or a combination of the two had no effect on ADG, DMI, or feed efficiency. However, by d 14, animals treated with the combination of Se and vitamin E had increased serum Se concentrations ($P < 0.05$). By d 7, serum antibody titers (IgG) were higher ($P < 0.05$) for those animals receiving the combination of Se and vitamin E injections. Number of sick days per animal was not affected by any of the treatments. Larsen et al. (1988) studied the effect of Se supplementation on the antibody response to tetanus toxoid and on serum IgG levels in sheep. Sheep previously fed a marginally deficient Se diet were used. The six treatments consisted of 0.1, 0.5, or 1.0 mg/kg Se, as either sodium selenite or selenomethionine. Animals were immunized against PI_3 virus, clostridial diseases, and tetanus. They found a tendency for increased antibody and IgG production from Se supplementation.

Pollock et al. (1994) studied the effect of dietary vitamin E and Se on in vitro cellular immune responses in cattle. Sixteen 7-mo-old calves were randomly assigned to four dietary treatments: low vitamin E/low Se, high vitamin E/low Se, low vitamin E/high Se, and high vitamin E/high Se. After 35 wk, all calves were innoculated with keyhole limpet haemocyanin (KLH). Three weeks later the treatment was repeated. The low vitamin E/high Se group showed the greatest response in terms of lymphocyte activity to the KLH immunization. Calves supplemented with vitamin E had more lymphocytic activity in response to KLH immunization than calves not supplemented with vitamin E.

Byproduct feeds—soy hulls and corn gluten feed

Byproduct feeds, if readily available, can sometimes be substituted for or used in combination with more traditional feeds such as corn or soybean meal, in supplements for beef calves. In the Southeast United States, both corn gluten feed and soy hulls are available to producers for use in supplementation programs.

Soy hulls are the seed coats of soybeans removed prior to crushing for soybean oil (Blasi et al., 2000). Soy hulls are high in digestible fiber, and contain approximately 77% TDN, 14% CP, and 14% starch (NRC, 2000). Compared to more starchy feeds, soy hulls have a lower rate of fermentation, resulting in fewer problems with acidosis (Martin and Hibberd, 1990). Hoover (1986) studied the effects of the low starch content of soy hulls compared to high starch concentrates. Soy hulls elicited better fiber digestion than the higher starch feeds. Hoover concluded that this increase of fiber digestion efficiency was probably due to the lack of decreased fibrolytic activity usually resulting from feeding high starch feeds such as corn. By providing a low starch alternative to corn, Hoover suggested that the microbial populations in the rumen remained in balance, and low ruminal pH and acidosis were avoided. Garces-Yepez, et al. (1997) concluded that feeding traditionally high starch supplements such as corn may lead to reduced ruminal pH and fiber digestibility.

Blasi et al. (1999) described the corn wet milling process as follows: during the wet milling process, corn is steeped in water and sulfur dioxide to swell the kernels. The resulting slurry is ground, screened, and then centrifuged to separate the gluten. Corn gluten feed consists of the shelled corn remaining after the extraction of starch, gluten, and germ in the wet milling manufacture of corn starch and corn syrup.

Brown and Weigel (1993) and Brown (1994), studied the effects of byproduct feeds with high digestibility and lower starch and sugar concentrations on feed intake of beef cattle. They concluded that the byproduct feeds with lower starch and sugar content had a less depressing effect on forage intake and digestibility than feedstuffs with higher levels of the starch and sugars. Kunkle et al. (1995) compared corn gluten feed, wheat middlings, and soybean hulls with corn supplementation at rates of 0.5% or 1.0% of BW. Steers were fed similar TDN concentrations. Corn was fed at 0.94% BW and soy hulls were fed at 1.16% BW. The cattle fed corn had lower gains and reduced forage intake than the steers fed soy hulls. Gains of steers fed wheat middlings were intermediate. Gains for all three supplement types at 0.5% BW were similar.

Arosemena et al. (1995) obtained samples of soy hulls, beet pulp, rice bran, almond hulls, citrus pulp, wheat mill run, bakery waste, brewers grains, and distillery grains, and performed chemical analyses to determine variability within feed sources. They analyzed samples for DM, ash, CP, fiber fractions, macrominerals, and microminerals. The analyzed variables were compared against the reported 1996 NRC values. Arosemena et al. concluded that variances in nutrient composition could be attributed to differences in plant varieties, processing methods, and handling of the feed after processing. Fiber values agreed with the NRC reported values, but there were significant differences in reported and analyzed values for Ca, P, Na, Fe, and Se. The analyzed values were higher than the reported values from the NRC. Although soy hulls have high ADF, they have a low ADL. Arosemena et al. suggested that fiber components were similar among all sources, which makes soy hulls a good potential fiber source for ruminant diets.

Batajoo and Shaver (1998) conducted in situ trials to determine DM, CP, and starch degradabilities of corn gluten feed and soy hulls. Dacron bags containing 6 g of sample (as fed) were immersed in the ventral rumen in duplicate for 2, 4, 6, 12, 24, 48, and 72 h. Ruminal degradation of DM was 56.9% for corn gluten feed and 48.8% for soy hulls. Ruminal availability of CP was 70.3% in corn gluten feed and was 58.2% in soy hulls. Ruminal availability of starch was 70.6% for corn gluten feed and 66.4% for soy hulls.

Zervas et al. (1998) investigated the effects of replacing corn with soy hulls in the diets of lactating ewes. Forty-five mature ewes were randomly assigned to three treatments: 400 g chopped ryegrass hay + 600 g concentrate with corn, 400 g chopped ryegrass hay + 600 g concentrate with soy hulls, and 400 g chopped ryegrass hay + 600 g concentrate with 95% soy hulls and 5% soybean oil (w/w). Ewe weights were obtained at the beginning and the end of the 7-week trial period. Milk weights were also measured three times during the experimental period. Body weight increased over the 7 wk experimental period, but was not different between groups. Milk weights also did not vary between groups. The researchers concluded that replacing corn with soy hulls did not affect performance of lactating ewes.

Sanz Sampelayo et al. (1998) conducted a study to determine the effects of different protein sources in the diets of lactating goats. The protein sources used were faba beans, sunflower cake, corn gluten feed, and cottonseed. Twenty Granadina goats were randomly assigned to the four protein sources. For each diet, 20 percent of the protein was provided by the different sources. The goats consumed the experimental diets for 19 d. The first 14 d were a period of adaptation, and the remaining 5 d were the experimental period. Goats were milked by hand twice per day. Aliquots of milk were obtained for CP analysis. Overall milk yield was not affected by dietary protein source. The diet containing corn gluten feed as the protein source produced the highest milk CP percentage. No other significant effects of diet on milk suitability for cheese production were noted.

Moore et al. (2002) evaluated different by-product feeds for meat goats. The study objectives were to find feeds that would economically fit in a goat-finishing program, that would minimize negative changes in the rumen environment, and be highly digestible, available at a low cost, be palatable to the meat goats, and produce an acceptable carcass. Twenty-four

Boer and Boer cross wethers were randomly assigned to four dietary treatments: ad-libitum orchardgrass hay, wheat middlings fed at 1% BW + ad-libitum orchardgrass hay, soybean hulls fed at 1% BW + ad-libitum orchardgrass hay, or corn gluten feed fed at 1% BW + ad-libitum orchardgrass hay. Soy hulls were supplemented with soybean meal to equalize protein concentration with wheat middlings. During the 72 d performance phase, goats were weighed every 2 wk. An 8 d adaptation period to acclimate goats to fecal collection bags followed the 72 d performance trial. On the day following the last fecal collection, ruminal fluid was collected from each animal and pH and ruminal volatile fatty acid (VFA) profiles were determined. No differences were found between the live weights of the goats. However, carcass weights were heavier for goats fed the corn gluten feed. Carcasses from goats fed soy hulls or wheat middlings were heavier than carcasses from the control group consuming hay alone. Serum urea-N concentrations were highest from goats consuming the corn gluten feed diets. Goats fed soy hull and hay only diets had higher acetate:proprionate ratios than the goats fed corn gluten feed or wheat middlings. One concern with both the corn gluten feed and wheat middlings was the relatively high P content in the feeds. This could be an issue with urinary caliculi in long term feeding programs. The goats consumed less hay when being offered a by-product feed as a supplement. Because there were no differences in performance, the researchers concluded either soy hulls, wheat middlings, or corn gluten feed could be used in growing diets for meat goats.

Objectives

The overall objective for these experiments was to determine the effects of various forage to concentrate ratios and supplements on the performance and health of beef calves in backgrounding systems. The specific objectives were to:

1) compare different forage to concentrate ratios in drylot backgrounding diets.
2) evaluate the value of byproduct feedstuffs in backgrounding diets
3) compare the effects of fibrous feeds versus starchy feeds in backgrounding diets
4) to study the effects of Se and vitamin E injections individually and in combination

Experimental Procedures

Drylot Study.

Thirty-seven Angus and Angus crossbred steer calves were purchased on October 8, 2002 at the Wytheville, VA Feeder Cattle sale, and an additional 11 calves were purchased on October 9, 2002 at the Dublin, VA Feeder Cattle sale. Both groups of calves were shipped to the Smithfield Ruminant Nutrition and Equine Center in Blacksburg, VA. The 6-wk study started on October 10, 2002. The calves from Wytheville were fed grass hay for 1 d upon arrival at Smithfield and the start of the study. The 48 calves (203.0 kg) were blocked according to order through the chute into eight blocks of six, and then randomly allotted within blocks to six treatments arranged in a 2x3 factorial. The two dietary treatments were 40:60 and 70:30 forage to concentrate diets. The concentrate was corn + SBM and the forage was fescue-clover hay. MuSe® was used for the selenium injections. MuSe® contains 5 mg of Se and 50mg vitamin E as alpha tocopherol per ml. Selenium and vitamin E injection treatments were as follows: a control group receiving no Se or vitamin E injections, Se only (0.05 mg/kg Se), and vitamin E only (1500 I.U. vitamin E). Injections were made on d 0 and 28. The steers were trained to enter individual stalls at 1500. Steers were fed once daily and kept in stalls until 0800 the following morning. They had access to water during the day in outside drylot pens. The 40:60 diet was mixed in 454.5 kg batches for 15 min each in a Davis horizontal mixer (H. C. Davis Sons MFG Co. Inc., Bonner Springs, KS). The 70:30 diet was mixed in the same mixer (272.7 kg batches) for 15 min. Feed samples were collected from each batch of feed mixed and from individual ingredients at time of mixing and stored in plastic bags until time of analysis. The diets were isonitrogenous (10% CP). Ingredient composition of the two diets is presented in Table 1.

Pasture Study 1 - Nutrient Management, Shenandoah Valley Agricultural Research and Extension Center (SVAREC).

Thirteen Angus and Angus crossbred steers were purchased on October 28, 2002 from the Marshall, VA Feeder Cattle sale and 35 steers were purchased on October 30, 2002 from the Dublin, VA Feeder Cattle sale. Both groups of steers were shipped to the Shenandoah Valley Agricultural Research and Extension Center (SVAREC) in Steeles Tavern, VA. The 48 steers (201.6 kg) started the 6-wk trial on October 31, 2002. The steers from Marshall were fed grass hay during the 2 d prior to the starting date. This experiment was a 4x3 factorial with four pasture treatments and three supplement treatments. The four pasture treatments were: no fertilizer, poultry litter fed to previous grazing cattle, poultry litter applied directly to the field, and inorganic fertilizer applied to the field. The three supplement treatments were: no supplement, soy hulls + SBM (16% CP), and corn + SBM (16% CP), each fed at 0.5% BW.

Table 1. Ingredient composition of Smithfield drylot diets.

Ingredient	IFN	Forage:concentrate diets 40:60	Forage:concentrate diets 70:30
		------------------%[a]------------------	
Grass-legume hay	1-02-301	40.32	70.31
Corn grain	4-02-861	57.02	26.71
Soybean meal	5-20-637	1.52	2.02
Dicalcium phosphate	6-26-335	--	0.13
Limestone	6-02-632	0.69	0.38
Trace mineralized salt		0.45	0.45

[a] As-fed basis

[b] 44% CP, solvent extracted

The calves were blocked according to order through the chute into four blocks of 12 animals. The 12 animals within each of the four blocks were randomly allotted to the four treatments of stockpiled fescue pastures. The three blocks within each pasture treatment were randomly allotted to the three supplement treatments. The supplements were mixed in 454.5 kg batches for 15 min in a Davis horizontal mixer (H. C. Davis Sons MFG Co. Inc., Bonner Springs, KS). Feed samples were collected from each batch of feed mixed before being bagged and from individual ingredients at time of mixing. Samples were stored in plastic bags until analysis. During the study, animals were kept on pasture. From d 0 to d 7, animals had access to 0.567 ha of pasture. From d 8 to d 42, animals had access to 1.03 ha of pasture. Animals were fed once daily at approximately 0800. Trace mineralized salt blocks (Cargill, Inc., Minneapolis, MN) were provided to all pastures. The salt blocks contained 38% Na, 0.35% Zn, 0.2% Fe, 0.2% Mn, 0.03% Cu, 0.01% I, and 0.01% Co on an as-fed basis. The supplement ingredient composition is presented in Table 2.

Pasture Study 2 - Heifer Development (SVAREC).

This 6-wk study started on October 16, 2002. Thirty-six Angus crossbred heifer calves produced at SVAREC (244.2 kg) were blocked according to cow system into six groups of six animals. The six groups were allotted at random to six pastures (1.86 ha each). The six pastures allotted at random to three supplements: corn gluten feed + soy hulls fed at 0.5% BW, corn gluten feed + soy hulls fed at 1.0% BW, or soy hulls + SBM fed at 0.5% BW (Table 2). The supplements were mixed in 454.5 kg batches for 15 min in a Davis horizontal mixer (H. C. Davis Sons MFG Co. Inc., Bonner Springs, KS). Feed samples were collected from each batch of feed mixed before being bagged and from individual ingredients at time of mixing. Samples

Table 2. Supplement ingredient composition.

		16% CP[a] supplement		
Ingredient	IFN	CGF[b] + SH[c]	SH[c] + SBM[d]	Corn + SBM[d]
Corn gluten feed (pelleted)	5-02-903	66.90	--	--
Soy hulls (pelleted)	1-04-560	33.10	90.50	--
SBM[d]	5-20-637	--	9.50	14.60
Corn	4-02-861	--	--	85.40

[a] Calculated, dry matter basis
[b] Corn gluten feed
[c] Soy hulls
[d] Solvent extracted soybean meal, 44% CP

were stored in plastic bags until analysis. Animals were kept on pasture for the duration of the study. The heifers were fed once daily at approximately 0800. A loose mineral mixture (King Ag Products, Inc., Pulaski, VA) containing 10.70% Ca, 8.5% P, 11.7% Na,1.10% K, 11.2% Mg, 1.90% S, 5,100 ppm Zn, 3,970 ppm Mn, 2,500 ppm Cu, 136 ppm I, 97 ppm Co, 120 ppm Se, 15,7181 I.U. vitamin A per kg, 38,909 I.U. vitamin D_3 per kg, and 227 I.U. vitamin E per kg was available in all pastures.

Pasture Study 3 - Big Meadow (SVAREC).

This 6-wk study started on October 16, 2002. At weaning, 48 Angus and Angus crossbred steer calves produced at SVAREC (254.1 kg) were blocked into groups of four according to prior cow system. Within each block the animals were allotted at random to the four paddocks (1.21 ha each) near the Big Meadow pasture. The 12 animals within each paddock were randomly allotted to four injection treatments: no Se or vitamin E, Se only (0.05 mg/kg Se), vitamin E only (1500 I.U. vitamin E), or a combination of Se and vitamin E (0.05 mg/kg Se + 1500 I.U. vitamin E). Injections were made on d 0 and 28. Steers remained outdoors on pasture for the duration of the study, and were fed a grass-legume hay when pasture foraged was limited. All animals had access to plain white salt (Cargill, Inc., Minneapolis, MN) without additional Se.

Pasture Study 4 - Kentland.

Forty-eight Angus and Angus crossbred steer calves (203.6 kg) were purchased on October 23 from the Dublin, VA Feeder Cattle sale and shipped the following morning to Kentland Farm in Blacksburg, VA. The 6-wk study started on October 24, 2002. The calves were blocked according to order through the chute into six blocks of eight animals. Within blocks, the calves were allotted at random to eight pastures (0.61 ha each): four stockpiled fescue pastures and four stockpiled fescue + alfalfa pastures. In this 2x3 factorial arrangement, forages were fescue and fescue-alfalfa and the three injection treatments were no injection, Se only (0.05 mg/kg Se), or vitamin E only (1500 I.U. vitamin E). Within each pasture, animals were randomly allotted to the three injection treatments. Injections were made on d 0 and 28. Calves in the fescue + alfalfa pastures had access to mineral blocks containing 65.95 g poloxalene per kg (PM Ag products, Homewood, IL) to prevent bloat. These blocks contained 4% CP, 5% Ca, 4% P, 2%K, 1% Mg, 69 ppm I, 27 ppm Cu, 21.6 ppm Se, 540 ppm Zn, and 220 I.U./kg vitamin E, on an as-fed basis. Trace mineralized salt blocks (Cargill, Inc., Minneapolis, MN) were provided in all pastures, also. The salt blocks contained 38% Na, 0.35% Zn, 0.2% Fe, 0.2% Mn, 0.03% Cu, 0.01% I, and 0.01% Co on an as-fed basis. Animals remained on pastures and were rotationally grazed within forage type for the duration of the study.

Protocol for all trials

For calves born at SVAREC, d 0 was the day calves were weaned. Upon weaning or arrival, calves were treated with Cydectin® pour-on anthelmintic (Fort Dodge Animal Health, Fort Dodge, IA). Calves produced at SVAREC (Big Meadow and Heifer Development pasture studies) were vaccinated 5 wk prior to weaning for bovine respiratory disease (BRD) infectious bovine rhinotracheitis (IBR), parainfluenza (PI_3), bovine viral diarrhea (BVD), and bovine respiratory syncytial virus with Pyramid 4® (Fort Dodge Animal Health, Fort Dodge, IA) and for clostridial disease with Vision 7® (Intervet, Boxeer, Netherlands). Purchased calves in the Smithfield drylot study and Nutrient Management and Kentland pasture studies were vaccinated upon arrival with Pyramid 4® and Vision 7®.

Cattle were weighed, blood samples were obtained, and rectal temperatures were taken on d 0, 7, 14, 28, and 42. Blood samples were collected via jugular venipuncture into

Vacutainer^{TM} blue cap blood collection tubes (Becton Dickinson Corporation, Franklin Lakes, NJ) Zn analysis and red cap tubes for all other serum analysis. Blood samples were centrifuged at 600 x g for 15 minutes, and the serum was decanted into a clean tube and frozen until analysis.

Cattle receiving supplements on pasture were fed a small amount of supplement on d 1. The amount fed was increased by 0.25 kg per day until the appropriate amount of supplementation was reached. The quantity of supplement fed to each group of animals was recalculated following each weigh date to reflect the average body weight of the calves in that particular pen. Refusals were weighed back and recorded.

The drylot study cattle were fed 4.54 kg of grass hay on d 0. On d 1 they were fed 3.64 kg grass hay and 0.90 kg of their respective experimental diets. From d 1 to d 5, the amount of hay fed was decreased by 0.90 kg per d and the amount of experimental diet was increased by 0.90 kg per d up until d 5, at which time the steers were consuming only the experimental diets. The amount of feed offered was increased by 0.45 kg if the animal consumed all that was offered for two consecutive feedings. When the steer refused 1 kg or more, feed offered was reduced by 0.5 kg. This procedure continued throughout the study. Refusals were weighed and recorded daily, and refusals were discarded.

Morbidity scores were assigned to animals each morning during feeding. These scores were based on a subjective scoring system described in Table 3 (Perino and Apley, 1998). Sick animals were identified by the presence of nasal discharge, lethargy, failure to eat or drink, coughing, and separation from the group. Any animal with a score of 3 or higher was brought to the chute, and the temperature was taken. If the temperature was above 40^{o} C, the animal was treated with Micotil® (tilmicosin) (Elanco Animal Health, Indianapolis IN)

Table 3. Morbidity scoring system.

Score	Description
1	Normal, no signs of disease.
2	Noticeable depression, signs of weakness are usually not apparent.
3	Marked depression, moderate signs of weakness may be apparent, but without significantly altered gait.
4	Severe depression accompanied by signs of weakness such as altered gait or lowered head.
5	Moribund, unable to rise.

according to label specifications. If illness recurred, the animal was treated with NuFlor® (Florfenicol) (Schering Plough Animal Health Corp., Madison, NJ).

Forage quality samples were taken by grab samples with hand-held clippers on d 0, 7, 14, 28, and 42. Samples were taken every 10 paces while walking a criss-cross pattern in each paddock. Samples were collected at an estimated grazing height of 2.5 cm. Samples were dried for 48 h in a forced draft oven at 60° C and then stored in cloth bags until later analysis. Forage mass samples were collected on d 0, 14, 28, and 42 using a push mower (American Honda Motor Co., Duluth, GA) at a height of 2.5 cm. Two 3.0 x 0.5 m strips were mowed at random per paddock for the Kentland, Nutrient Management, and Big Meadow studies. Four 3.0 x 0.5 m strips were mowed at random per paddock for the Heifer Development study. The samples were dried in cloth bags in a forced draft oven for 72 hr before weighing. Hay samples were collected with a core sampler. Hay samples were stored in plastic bags at room temperature until later analysis.

Chemical Analyses

All feed ingredients, experimental diets, and pasture samples were sampled and ground through a 1-mm screen using a Wiley mill (Thomas Wiley, Laboratory Mill Model 4, Arthur H. Thomas Co. Philadelphia, PA). Percent dry matter was determined by drying samples for 24 h at 100° C. Ash determination was made by putting samples in a muffle furnace for 3 h at 500° C (AOAC, 2000). Crude protein was determined via the combustion method (AOAC, 2000) using a nitrogen analyzer (PerkinElmer 2410, Norwalk, CT). Analysis for all feed ingredient and mixed feed samples was performed to determine NDF and ADF using a fiber analyzer (Ankom^{200}, Fairport, NY). Lignin and cellulose were also determined (Goering and Van Soest, 1970). Hemicellulose was calculated as the difference between the NDF and ADF fractions. Samples were digested for mineral analysis with 2:1 (v/v) HNO_2: $HClO_4$ (Muchovej, et al., 1986). Calcium, Mg, K, Cu, and Zn were analyzed by flame atomic absorption spectroscopy (PerkinElmer 5100 PC, Norwalk, CT) and Se was analyzed using the graphite furnace on the same instrument. The colorimetric method of Fiske and Subbarow (1925) and a Titertek Multiskan® MCC/340 (Titertek, Huntsville, AL) was used to determine feed sample P.

Serum P and serum urea nitrogen (SUN) were analyzed using an autoanalyzer (Beckman SYNCHRON CX SYSTEMS®, Beckman Instruments, Inc., Brea, CA). The SUN concentration of samples involved a SUN enzymatic rate reagent. The enzymatic reaction between the serum sample and the reagent causes a change in the absorbance at 340 nm. The change in absorbance is directly proportional to the concentration of SUN in the serum. The SYNCHRON CX System calculates the SUN concentration of the serum sample. Phosphorus concentration in the serum samples was analyzed using a molybdate reagent and the resulting colorimetric reaction.

Serum samples were analyzed for alpha tocopherol (vitamin E) according to the method described by Miller and Yang (1985) and Craig et al. (1989) using an HPLC (Agilent Technologies, 1100 series, Wilmington, DE) fitted with a 0.01 u pore C18 column. Samples were prepared using 100 ul each of serum and an internal tocol standard. The serum and tocol were mixed with 600 ul of hexane and centrifuged for 1 min, which caused any fat soluble vitamins, including vitamin E, to separate out of the serum and into the hexane layer. The hexane layer was then pipetted off and evaporated under a N evaporation unit (N-EVAP^{TM} 111, Organomation Associates, Inc., Berlin, MA). The sample was then resuspended in 100 ul of ethanol for HPLC analysis. The carrier solvent for the isocratic analysis was methanol. The alpha tocopherol concentration was calculated as the area under the curve during the retention period in the column.

Statistical analyses

Statistical analysis was by GLM (SAS, 1999) procedure for analysis of variance for a completely randomized block design. Tukey’s one-way analysis of variance test was used to compare treatment and forage type effects and forage type x treatment interactions. The animal was the experimental unit for individual measurements and the pen was the experimental unit for hay and supplement intake. All means are reported as least squares means (LSM).

Results

Chemical Composition of Feeds.

Chemical composition of the diets fed in drylot is presented in Table 4. The 40:60 forage to concentrate diet had lower levels of NDF, ADF, and cellulose than the 70:30 diet. This was due to the lower percentage of hay in the 40:60 diet. Dry matter content was similar between the two diets. Potassium concentration was lower ($P < 0.05$) and Zn concentration was higher ($P < 0.05$) for the 40:60 diet. Chemical composition of supplements is presented in Table 5. The corn gluten feed + soy hulls supplement had the highest ($P < 0.05$) average ash concentration. The SBM + soy hulls and corn gluten feed + soy hulls supplements had less than 15% analyzed CP, while the corn + SBM supplement had slightly more than 15% CP. The corn + SBM supplement had lower concentrations of Ca, Mg, K, and Cu than either the soy hulls + SBM or corn gluten feed + SBM supplements. Phosphorus was highest ($P < 0.05$) for the corn gluten feed + soy hulls supplement and lowest ($P < 0.05$) for the corn + SBM supplement.

Chemical composition of hay fed to steers in pasture study 3 is presented in Table 6. Analyzed values for CP were similar to those reported in the NRC (2000). Analyzed values for mineral composition and fiber components of hay in the present study were also similar to those reported in the NRC (2000).

Drylot Study.

Performance. Performance data for the drylot-fed steers are presented in Table 7 and steer weights over time are shown in Figure 1. There were no interactions between diet treatment and injection treatment on any day. No differences were detected in initial weights across blocks or treatments. No significant differences were detected in cumulative daily gains due to either forage:concentrate ratio or injection treatment on any days. Dry matter intake was

Table 4. Chemical composition of drylot diets.

	Forage:concentrate		
Item	40:60	70:30	SEM
Dry matter, %	91.4[b]	91.75[c]	0.001
Ash, %[a]	6.41[b]	7.78[c]	0.001
Crude protein, %[a]	9.06[b]	10.61[c]	0.001
Neutral detergent fiber, %[a]	35.69[b]	49.27[c]	0.222
Acid detergent fiber, %[a]	17.29[b]	25.82[c]	0.861
Cellulose, %[a]	12.98[b]	23.01[c]	0.048
Lignin, %[a]	0.43	0.53	0.024
Calcium, %[a]	0.72	0.67	0.010
Magnesium, %[a]	0.22	0.25	0.010
Phosphorus, %[a]	0.35	0.36	0.092
Potassium, %[a]	1.80[b]	2.27[c]	0.010
Copper, ppm[a]	2.20	0.93	0.048
Zinc, ppm[a]	4.64[b]	3.87[c]	0.162
Selenium, ppm[a]	0.143	0.183	0.016

[a] Dry matter basis

[b,c] Means within a row with different superscripts are different ($P < 0.05$).

Table 5. Chemical composition of supplements.

	Supplements, 15% CP[a]			
Item	SH[b] + SBM[c]	CGF[d] + SH[b]	Corn + SBM[c]	SEM
Dry matter, %	88.17	88.96	88.34	0.058
Ash, %[e]	5.13[f]	8.80[g]	2.35[h]	0.009
Crude protein, %[e]	13.62	14.38	15.47	0.619
Neutral detergent fiber, %[e]	61.39[f]	39.21[g]	30.08[g]	3.153
Acid detergent fiber, %[e]	43.49[f]	19.28[g]	4.98[g]	2.507
Cellulose, %[e]	20.61[f]	13.24[g]	12.02[g]	1.414
Lignin, %[e]	0.43[f]	0.57[g]	0.20[h]	0.028
Calcium, %[e]	0.75[f]	0.31[g]	0.06[h]	0.012
Magnesium, %[e]	0.29[f]	0.41[g]	0.16[h]	0.007
Phosphorus, %[e]	0.19[f]	0.76[g]	0.38[h]	0.015
Potassium, %[e]	1.81[f]	1.70[g]	0.72[h]	0.032
Copper, ppm[e]	7.97[f]	4.59[g]	5.09[h]	0.014
Zinc, ppm[e]	3.86[f]	3.34[g]	3.35[g]	0.131
Selenium, ppm[e]	0.07[f]	0.19[g]	0.27[g]	0.028

[a] Calculated, DM basis.

[b] Soy hulls, pelleted.

[c] Soybean meal, solvent extracted, 44% CP.

[d] Corn gluten feed, pelleted.

[e] Dry matter basis.

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

Table 6. Chemical composition of hay fed to steers[a]. Big Meadow.

Item	Concentration
Ash, %	7.31
Crude protein, %	11.23
Neutral detergent fiber, %	68.11
Acid detergent fiber, %	36.64
Cellulose, %	5.09
Lignin, %	0.35
Calcium, %	0.53
Magnesium, %	0.27
Phosphorus, %	0.26
Potassium, %	2.55
Copper, ppm	5.66
Zinc, ppm	21.08
Selenium, ppm	0.230

[a] Dry matter basis.

Table 7. Effect of forage to concentrate ratio and selenium and vitamin E injections on performance of drylot fed steers.

Item	Forage:concentrate		Injection			SEM
	40:60	70:30	None	Vitamin E	Selenium	
	--------------------------------------kg--------------------------------------					
Initial weight	205.8	200.2	201.5	204.2	203.4	3.792
Cumulative ADG						
Day 7	0.19	0.66	0.43	0.55	0.32	0.696
Day 14	0.24	0.59	0.44	0.43	0.38	0.506
Day 28	0.63	0.83	0.72	0.71	0.76	0.299
Day 42	0.74	0.77	0.72	0.71	0.78	0.205
Daily DM intake[a]	3.60	3.86	3.72	3.68	3.78	0.586
Gain:feed DM	0.21	0.19	0.19	0.19	0.21	0.020

[a] Dry matter basis

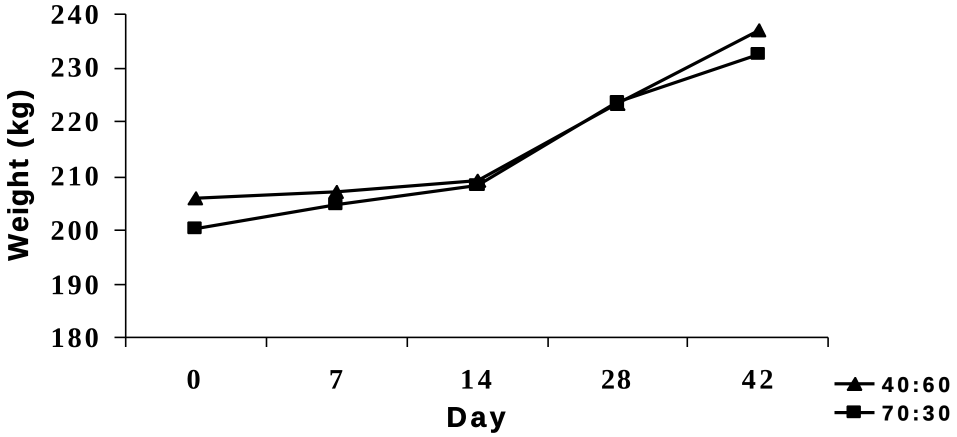

Figure 1. Effect of forage to concentrate ratio on weights of drylot fed steers.

similar between all treatments. There were no significant differences in gain:feed between all treatments.

Rectal Temperatures, Morbidity Scores, and Treatments. Rectal temperatures, morbidity scores, and health treatment data are presented in Table 8. No differences were detected in rectal temperatures due to forage to concentrate ratio or injection treatment throughout the trial. Morbidity scores are reported as weekly averages. Morbidity from d 0 to d 7 was higher ($P < 0.05$) in animals consuming the 40:60 percent forage to concentrate diet, but differences were small. No other significant differences in morbidity were detected for the duration of the study, either due to diet treatment or injection treatment. For all animals, morbidity was highest between d 8 and d 14, but diet and injection treatment had no significant effect.

The number of animals treated was high from d 8 to d 28. A total of 35 animals were treated, and 10 were treated more than once. Seven of the 35 animals were treated because of a morbidity score of 3 or higher. Twenty-eight were treated based on elevated temperatures on sampling days.

Blood Serum Mineral Concentrations. Serum mineral concentrations are presented in Table 9. On d 0 of the trial, serum concentrations of Ca, Mg, K, P, and Zn were similar across treatments. Serum Cu was higher ($P < 0.05$) in steers in the vitamin E and Se injection treatment groups than in the control injection group. This difference was random, as blood samples were obtained prior to administering the injection treatments. No differences were recorded among treatments on d 7. On d 14 and 28, steers fed the 40:60 forage to concentrate diet had higher ($P < 0.05$) Cu concentrations than steers fed the 70:30 forage to concentrate diet. On d 42, steers fed the 40:60 diet had higher ($P < 0.05$) serum Mg and Cu concentrations than

Table 8. Effect of forage to concentrate ratio and selenium and vitamin E injections on rectal temperatures, morbidity and treatment of drylot fed steers.

	Forage:concentrate		Injection			
Item	40:60	70:30	None	Vitamin E	Selenium	SEM
Rectal temperatures[a]						
Day 0	39.71	39.55	39.67	39.63	39.59	0.161
Day 7	39.70	39.43	39.68	39.38	39.63	0.259
Day 14	39.25	39.67	39.21	39.67	39.50	0.236
Day 28	39.04	38.91	38.99	39.01	38.93	0.148
Day 42	39.25	39.45	39.29	39.65	39.17	0.184
Morbidity[b]						
Day 0	1.00	1.00	1.00	1.00	1.00	0.000
Day 1-7	1.04[d]	1.00[e]	1.01	1.02	1.04	0.023
Day 8-14	1.13	1.13	1.12	1.61	1.11	0.089
Day 15-28	1.02	1.04	1.04	1.05	1.01	0.028
Day 29-42	1.02	1.02	1.01	1.03	1.01	0.016
Treated[c]						
Day 0	--	--	--	--	--	
Day 1-7	--	1	--	--	1	
Day 8-14	12	9	9	6	6	
Day 15-28	8	13	4	9	8	
Day 29-42	1	1	1	1	--	

[a] Degrees Celsius

[b] Based on a subjective scoring system (1 = healthy, 5 = moribund).

[c] Number of animals treated.

[d,e] Means within a row with different superscripts are different ($P < 0.05$).

Table 9. Effect of forage to concentrate ratio and vitamin E and selenium injections on serum mineral profile of drylot fed steers.

		Forage:concentrate		Injection			
Day	Item	40:60	70:30	None	Vitamin E	Selenium	SEM
0	Ca, mg/dl	11.97	11.79	12.09	12.56	11.01	1.734
	Mg, mg/dl	2.43	2.42	2.52	2.46	2.29	0.386
	K, mg/dl	34.23	34.41	35.97	32.94	34.64	1.637
	P, mg/dl	6.56	6.41	6.65	6.22	6.59	0.313
	Cu, ppm	7.64	7.56	6.83^{a}	7.92^{b}	8.04^{b}	0.409
	Zn, ppm	6.52	7.18	7.09	6.19	7.27	0.532
	Se, ppm	0.022	0.025	0.025	0.023	0.023	0.005
	Urea-N, mg/dl	10.43	10.70	10.17	10.96	10.58	0.751
7	Ca, mg/dl	9.88	10.42	10.01	10.59	9.86	0.488
	Mg, mg/dl	1.67	1.77	1.69	1.73	1.73	0.994
	K, mg/dl	33.91	36.08	35.60	34.10	35.28	2.020
	P, mg/dl	7.03	6.77	6.91	6.91	6.88	0.332
	Cu, ppm	9.50	9.17	9.44	9.63	8.93	0.563
	Zn, ppm	8.39	8.81	8.27	8.80	8.74	0.758
	Se, ppm	0.026	0.027	0.018^{a}	0.016^{a}	0.045^{b}	0.003
	Urea-N, mg/dl	6.62	7.19	7.08	6.86	6.77	0.856
14	Ca, mg/dl	15.32	13.42	15.54	13.96	13.61	2.645
	Mg, mg/dl	2.93	2.34	2.89	2.56	2.45	0.485
	K, mg/dl	29.61	28.21	29.80	27.98	28.96	0.956
	P, mg/dl	6.69	6.11	6.45	6.02	6.73	0.454
	Cu, ppm	9.87^{a}	8.82^{b}	9.06	9.48	9.51	0.470
	Zn, ppm	7.83	7.41	7.79	7.10	7.97	0.667
	Se, ppm	0.028	0.029	0.025^{a}	0.025^{a}	0.036^{b}	0.002
	Urea-N, mg/dl	6.19	7.87	5.88	8.83	6.41	1.656
28	Ca, mg/dl	11.50	11.94	11.80	12.15	11.21	0.705
	Mg, mg/dl	2.24	2.12	2.29	2.16	2.08	0.155
	K, mg/dl	28.98	28.46	28.79	28.62	28.75	1.143
	P, mg/dl	6.82	7.18	7.20	6.78	7.02	0.332
	Cu, ppm	11.80^{a}	10.31^{b}	10.33	11.31	11.54	0.596
	Zn, ppm	9.71	10.61	9.76	10.04	10.67	0.598
	Se, ppm	0.022	0.019	0.018^{a}	0.018^{a}	0.027^{b}	0.002
	Urea-N, mg/dl	5.34	5.98	5.69	5.63	5.66	0.540
42	Ca, mg/dl	10.69	11.20	10.90	11.32	10.61	0.887
	Mg, mg/dl	2.18^{a}	1.96^{b}	2.01	1.99	2.19	0.118
	K, mg/dl	32.10	33.40	32.16	32.71	33.34	2.435
	P, mg/dl	7.39	7.11	7.388	6.99	7.38	0.357
	Cu, ppm	10.97^{a}	8.76^{b}	8.38^{c}	11.75^{d}	9.47^{cd}	1.302
	Zn, ppm	11.71	9.57	11.87	9.07	10.10	0.761
	Se, ppm	0.020	0.018	0.014^{a}	0.012^{a}	0.031^{b}	0.002
	Urea-N, mg/dl	5.16^{a}	5.99^{b}	5.15	5.48	6.09	0.479

^{a,b} Means within a row with different superscripts are different ($P < 0.05$).
^{c,d} Means within a row with different superscripts are different ($P < 0.05$).

steers fed the 70:30 diet. On d 42, steers receiving vitamin E injections had greater serum Cu concentrations than steers receiving no injections. Initailly, steers receiving Se and vitamin E injections had higher ($P < 0.05$) serum Cu concentrations compared to controls. On d 42, Cu levels were higher for vitamin E injected steers compared to no injection. No differences were observed in blood Se concentrations due to forage to concentrate ratio. No differences were observed in blood Se concentrations of steers across injection treatments on d 0. On d 7, 14, 28, and 42, steers receiving Se injections had higher ($P < 0.05$) blood Se concentrations than steers receiving either no injection or a vitamin E injection.

Serum Urea-N. Serum urea-N (SUN) data are presented in Table 9. No differences in SUN concentrations were detected across treatments until d 42. On d 42, steers fed the 70:30 forage to concentrate diet had higher ($P < 0.05$) SUN concentrations than those fed the 40:60 forage to concentrate diet.

Serum Alpha-Tocopherol Concentrations. Serum alpha-tocopherol concentrations are presented in Table 10. No differences were detected across treatments on d 0. On d 7, steers injected with vitamin E had higher ($P < 0.05$) serum alpha-tocopherol concentrations than steers that received Se injection. Steers not receiving an injection of vitamin E or selenium were intermediate. No differences were detected among treatments on d 14, 28, and 42.

Pasture Study 1 –Nutrient Management, Shenandoah Valley Agricultural Research and Experiment Station (SVAREC)

Forage Mass and Composition. Forage mass and chemical composition data are presented in Table 11. There were no differences across pasture treatments in forage mass on any day. On d 0, pastures with poultry litter applied had higher ($P < 0.05$) NDF values than

Table 10. Effect of forage to concentrate ratio and vitamin E and selenium injections on alpha tocopherol concentrations of drylot fed steers.

	Forage:concentrate		Injection			
Day	40:60	70:30	None	Vitamin E	Selenium	SEM
	ng/?l					
0	5.49	4.78	5.09	4.94	5.38	0.645
7	3.92	3.94	3.69^{ab}	4.62^{a}	3.48^{b}	0.451
14	2.85	3.17	2.98	2.99	3.05	0.334
28	2.86	2.79	2.79	2.68	2.99	0.291
42	3.24	2.77	2.69	3.39	2.94	0.501

[a,b] Means within a row with different superscripts are different ($P < 0.05$).

Table 11. Effect of previous pasture treatment on forage chemical composition and mass of stockpiled tall fescue pasture. Nutrient Management.

Day	Item[b]	Previous pasture treatment[a]				SEM
		Control	Poultry litter fed	Poultry litter applied	Inorganic fertilizer	
0	Mass, kg/ha	391	713	645	743	94.30
	Ash, %	9.33	9.67	10.00	10.00	0.24
	CP,%	24.98	28.34	26.12	27.67	0.97
	NDF, %	44.19[cd]	44.21[c]	46.94[d]	44.47[c]	0.39
	ADF, %	17.42	17.84	19.56	19.25	1.11
	Cellulose, %	2.93[cd]	2.89[cd]	4.97[c]	2.19[d]	0.56
	Lignin, %	0.30	0.44	0.30	0.30	0.14
7	Ash, %	8.00[c]	9.00[cd]	10.00[d]	9.00[cd]	0.41
	CP,%	24.33	26.27	26.71	26.99	0.82
	NDF, %	30.58	42.14	41.09	41.50	5.22
	ADF, %	18.40	18.36	21.75	19.37	1.18
	Cellulose, %	1.83	4.44	2.46	2.90	0.92
	Lignin, %	0.37	0.38	0.49	0.46	0.14
14	Mass, kg/ha	414	503	688	1039	154.38
	Ash, %	10.00	10.00	10.00	10.33	0.17
	CP,%	22.08	23.34	22.91	23.21	0.64
	NDF, %	46.05	45.51	46.13	46.00	1.64
	ADF,	17.68	19.66	19.47	17.76	1.73
	Cellulose, %	3.28	2.58	2.48	2.45	0.33
	Lignin, %	0.68	0.47	0.51	0.45	0.10
28	Mass, kg/ha	1232	1378	1584	1848	172.30
	Ash, %	8.00	8.33	10.00	9.00	0.22
	CP,%	21.73	26.00	24.14	21.64	0.53
	NDF, %	42.47	43.99	43.00	40.80	1.64
	ADF, %	17.81	19.08	21.08	18.20	2.18
	Cellulose,	2.04	1.61	3.11	2.02	0.88
	Lignin, %	0.43	0.32	0.41	0.19	0.10
42	Mass, kg/ha	361[c]	1036[d]	987[cd]	1349[d]	148.37
	Ash, %	7.33	7.67	8.67	8.67	0.33
	CP,%	19.62	18.57	21.51	21.23	1.17
	NDF, %	48.19	49.22	45.37	45.05	1.52
	ADF, %	21.49	22.72	19.23	19.25	1.28
	Cellulose, %	3.12	3.13	2.23	1.97	0.50
	Lignin, %	0.77	0.71	0.52	0.69	0.08

[a] Three replicates for each previous pasture treatment.

[b] Dry matter basis.

[c,d] Means within rows with different superscripts are different ($P < 0.05$).

either pastures with poultry litter fed to previous grazing cattle or pastures fertilized inorganically. On d 0, the poultry litter fed pastures tended to have higher ($P > 0.05$) lignin concentrations than the other pastures. On d 7, pastures with poultry litter applied had higher ($P < 0.05$) ash content than control pastures. No differences were detected between previous pasture treatments on d 14, 28, or 42.

Forage mineral status data are presented in Table 12. On d 0, pastures on which inorganic fertilizer was applied had higher ($P < 0.05$) Mg concentrations than pastures on which poultry litter was fed to previous grazing cattle. Pastures receiving any type of fertilizer (litter fed, litter applied, or inorganic fertilizer) had higher ($P < 0.05$) P concentrations than the control pastures. On d 7, pastures fertilized with inorganic fertilizer had higher ($P < 0.05$) K concentrations than control pastures. Inorganically fertilized pastures and pastures with poultry litter applied had higher ($P < 0.05$) P content than control pastures. Pastures with poultry litter applied had higher ($P < 0.05$) Cu content than control pastures and those fertilized with inorganic fertilizer. Pastures receiving inorganic fertilizer had higher ($P < 0.05$) Se concentrations than pastures with poultry litter applied. On d 14, there were no differences across pasture treatments. On d 28, pastures fertilized with either inorganic fertilizer or applied poultry litter had higher ($P < 0.05$) K concentrations than control pastures. On d 28, pastures with poultry litter applied had higher ($P < 0.05$) Cu concentrations than pastures fertilized with inorganic fertilizer. On d 42, pastures fertilized with inorganic fertilizer and pastures with poultry litter applied had higher ($P < 0.05$) K concentrations than control pastures. Pastures with poultry litter applied had higher ($P < 0.05$) P concentrations than control pastures. Pastures

Table 12. Effect of previous pasture treatment on forage mineral profiles of stockpiled tall fescue pasture. Nutrient Management.

Day	Item[b]	Previous pasture treatment[a]				SEM
		Control	Poultry litter fed	Poultry litter applied	Inorganic fertilizer	
0	Ca, %	0.67	0.57	0.52	0.64	0.042
	Mg, %	0.42[cd]	0.39[c]	0.41[cd]	0.47[d]	0.019
	K, %	3.26	3.97	4.10	4.02	0.206
	P, %	0.41[c]	0.49[d]	0.49[d]	0.50[d]	0.014
	Cu, ppm	5.82	8.48	10.05	4.52	1.232
	Zn, ppm	28.24	24.49	29.68	28.93	2.046
	Se, ppm	0.21	0.22	0.23	0.29	0.006
7	Ca, %	0.82	0.73	0.59	0.74	0.064
	Mg, %	0.49	0.46	0.43	0.31	0.083
	K, %	2.06[c]	2.74[cd]	3.40[cd]	3.44[d]	0.300
	P, %	0.42[c]	0.46[cd]	0.48[d]	0.49[c]	0.012
	Cu, ppm	9.38[cd]	10.09[ce]	11.22[e]	8.18[d]	0.351
	Zn, ppm	32.09	34.35	35.42	32.32	2.258
	Se, ppm	0.21[cd]	0.24[cd]	0.20[c]	0.25[d]	0.011
14	Ca, %	0.61	0.59	0.57	0.59	0.066
	Mg, %	0.42	0.41	0.42	0.41	0.017
	K, %	3.11	3.71	3.75	3.58	0.169
	P, %	0.49	0.55	0.53	0.46	0.026
	Cu, ppm	5.84	6.89	7.19	4.44	0.774
	Zn, ppm	26.72	28.70	27.92	26.15	2.346
	Se, ppm	0.29	0.24	0.25	0.26	0.016
28	Ca, %	0.89	0.76	0.70	0.84	0.039
	Mg, %	0.56	0.48	0.46	0.48	0.020
	K, %	1.29[c]	2.18[cd]	2.88[d]	2.42[d]	0.105
	P, %	0.42	0.47	0.510	0.48	0.010
	Cu, ppm	4.89[cd]	4.83[cd]	6.33[c]	3.28[d]	0.549
	Zn, ppm	26.65	26.42	29.56	23.82	1.847
	Se, ppm	0.28	0.26	0.26	0.25	0.069
42	Ca, %	0.69	0.58	0.55	0.57	0.043
	Mg, %	0.47	0.42	0.42	0.42	0.014
	K, %	0.99[c]	1.75[cd]	2.55[d]	2.54[d]	0.215
	P, %	0.37[c]	0.38[cd]	0.42[d]	0.39[cd]	0.010
	Cu, ppm	3.98[cd]	4.19[cd]	5.31[c]	2.74[d]	0.383
	Zn, ppm	27.17	26.28	28.22	24.94	2.096
	Se, ppm	0.21	0.22	0.23	0.25	0.011

[a] Three replicates of each previous pasture treatment.

[b] Dry matter basis.

[c,d,e] Means within rows with different superscripts are different ($P < 0.05$).

with poultry litter applied also had higher ($P < 0.05$) Cu concentrations than the pastures fertilized inorganically.

Performance. Performance data are presented in Table 13 and steer weights are shown in Figure 2. There were no interactions between treatments on any day. No differences were detected in initial weight between treatments. On d 7, unsupplemented steers had higher ($P < 0.05$) daily gains than steers supplemented with corn + SBM. Steers supplemented with soy hulls + SBM were intermediate. No differences were detected in cumulative gains on d 14, 28, or 42. Supplement intake was not affected by previous pasture treatment or supplement treatment. Gain:supplement efficiency was also not affected by supplement or previous pasture treatment.

Rectal Temperatures, Morbidity Scores and Treatments. Rectal temperatures, morbidity, and treatment data are presented in Table 14. No differences in rectal temperatures were detected due to treatment for the duration of the trial Morbidity scores are reported as weekly averages. No differences in morbidity were detected across treatments for the duration of the study, and all values were low. Steers were treated between d 8 and d 28. Low morbidity scores with lack of differences may be due to few illnesses. Sixteen animals were treated, and only two were treated more than once. No differences were observed in number of ill calves due to treatment. None of the animals had morbidity scores higher than 3. All animals were treated based on elevated temperatures on sampling days.

Blood Serum Mineral Concentrations. Serum mineral concentrations are presented in Table 15. On d 0, steers supplemented with corn + SBM and soy hulls + SBM had higher ($P < 0.05$) serum Cu concentrations than unsupplemented steers. This effect was random, as steers were blocked by order through the chute and had not been exposed to pastures or supplements.

Table 13. Effect of supplement and previous pasture treatment on performance of steers grazing stockpiled tall fescue. Nutrient management.

				Previous pasture treatment[a]				
		16% CP supplement			Poultry litter			
Item	None	SH[b] + SBM[c]	Corn + SBM[c]	Control	Fed	Applied	Inorganic fertilizer	SEM
	kg							
Initial weight	196.2	205.9	202.6	205.4	208.8	194.2	197.8	16.878
Average daily gain								
Day 7	2.00^{d}	1.90^{de}	0.86^{e}	1.72	1.45	1.82	1.37	1.318
Day 14	1.57	1.55	1.08	1.44	1.39	1.59	1.18	0.908
Day 28	1.13	1.17	0.84	0.95	0.97	1.25	1.03	0.442
Day 42	0.97	0.98	0.85	0.77	0.88	1.06	1.03	0.378
Supplement intake[f]	--	1.02	0.96	0.98	1.03	0.96	0.97	0.025
Gain:supplement DM	--	0.96	0.89	0.79	0.85	1.10	1.06	0.153

[a] Three replicates of each previous pasture treatment.

[b] Soy hulls.

[c] Soybean meal, 44% CP, solvent extracted.

[d,e] Means within a row with different superscripts are different ($P < 0.05$).

[f] Dry matter basis

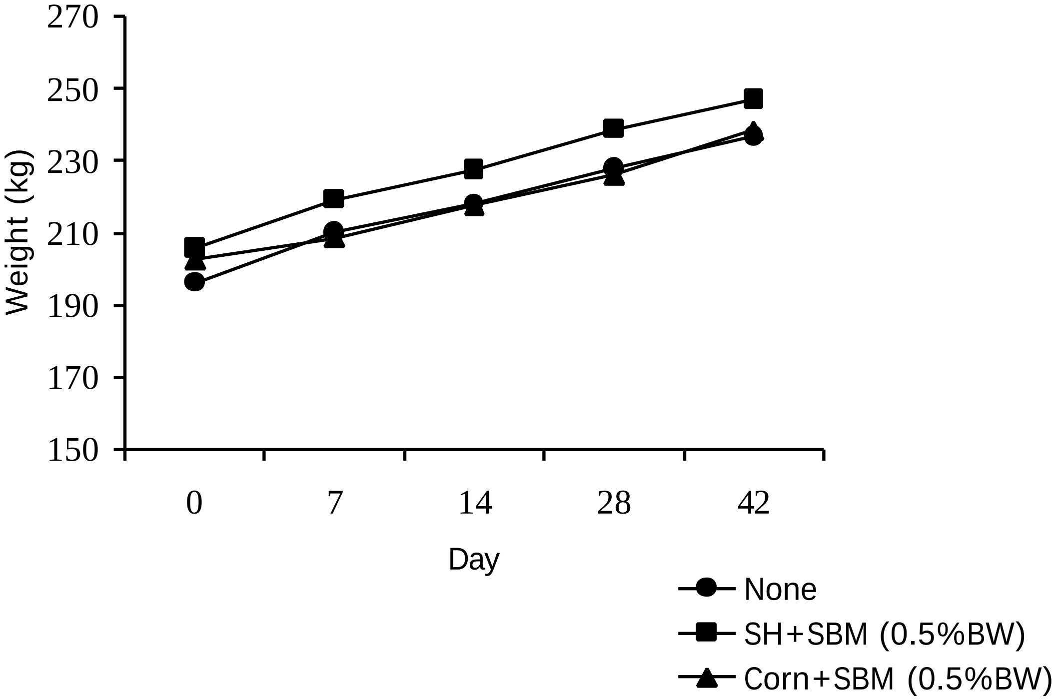

Figure 2. Effect of supplementation on weights of steers grazing stockpiled tall fescue pasture. Nutrient Management.

Table 14. Effect of supplement and previous pasture treatment on rectal temperatures, morbidity and treatment of steers grazing stockpiled tall fescue. Nutrient Management.

				Previous pasture treatment[a]				
		16% CP supplement			Poultry litter			
Item	None	SH[b] + SBM[c]	Corn + SBM[c]	Control	Fed	Applied	Inorganic fertilizer	SEM
Rectal temperatures[d]								
Day 0	39.63	39.40	39.40	39.58	39.48	39.58	39.61	0.194
Day 7	39.84	39.66	39.74	39.85	39.44	39.70	40.01	0.339
Day 14	40.05	39.74	39.37	39.77	39.88	39.39	39.84	0.281
Day 28	39.11	39.24	39.97	39.06	39.01	39.27	39.08	0.209
Day 42	39.44	39.48	39.63	39.45	39.44	39.60	39.58	0.164
Morbidity[e]								
Day 0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.000
Day 1-7	1.00	1.04	1.00	1.00	1.02	1.02	1.00	0.024
Day 8-14	1.00	1.02	1.00	1.00	1.00	1.00	1.02	0.021
Day 15-28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.000
Day 29-42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.000
Treated[f]								
Day 0	--	--	--	--	--	--	--	
Day 1-7	--	--	--	--	--	--	--	
Day 8-14	2	2	3	3	--	1	3	
Day 15-28	5	4	2	3	3	2	3	
Day 29-42	--	--	--	--	--	--	--	

[a] Three replicates of each previous pasture treatment.

[b] Soy hulls.

[c] Soybean meal, 44% CP, solvent extracted.

[d] Degrees Celsius

[e] Based on a subjective scoring system (1 = healthy, 5 = moribund).

[f] Number of animals treated.

Table 15. Effect of supplement and previous pasture treatment on serum mineral profiles of steers grazing stockpiled tall fescue. Nutrient Management.

					Previous pasture treatment				
			16% CP supplement			Poultry litter			
Day	Item	None	SH[a] + SBM[b]	Corn + SBM[b]	Control	Fed	Applied	Inorganic fertilizer	SEM
0	Ca, mg/dl	9.905	16.35	10.49	10.46	9.85	18.51	10.15	5.882
	Mg, mg/dl	1.01	2.16	2.02	1.99	2.05	2.05	2.18	0.734
	K, mg/dl	26.48	28.09	24.30	27.47	25.33	27.09	25.27	2.538
	P, mg/dl	6.38	6.69	6.31	6.56	6.38	6.13	6.76	0.519
	Cu, ppm	2.44[c]	5.34[d]	4.56[d]	2.50	4.83	4.74	4.39	1.187
	Zn, ppm	5.81	5.78	6.11	5.69	6.23	6.13	5.57	1.073
	Se, ppm	0.018	0.018	0.019	0.018	0.020	0.018	0.017	0.005
	Urea-N, mg/dl	14.12	15.43	13.69	14.17	14.34	14.36	14.78	1.419
7	Ca, mg/dl	10.97[cd]	11.13[c]	10.61[d]	11.04	10.92	10.92	10.73	0.285
	Mg, mg/dl	2.18	2.12	2.13	2.08	2.15	2.19	2.14	0.367
	K, mg/dl	27.66	28.19	25.33	27.67	27.58	26.65	26.37	1.734
	P, mg/dl	6.50	6.28	6.77	6.12	6.91	6.68	6.37	0.637
	Cu, ppm	7.27	8.52	6.80	7.75	7.77	7.32	7.27	1.232
	Zn, ppm	8.01	8.90	8.39	8.53	9.27	7.78	8.17	1.101
	Se, ppm	0.016[cd]	0.018[c]	0.012[d]	0.015	0.017	0.014	0.014	0.003
	Urea-N, mg/dl	18.48[c]	17.32[cd]	15.21[d]	14.87[e]	17.34[ef]	18.04[f]	17.76[ef]	1.335
14	Ca, mg/dl	17.00[cd]	19.99[c]	14.49[d]	17.40	15.14	16.08	20.01	2.578
	Mg, mg/dl	3.70[cd]	4.65[c]	2.98[d]	4.03	3.28	3.36	4.43	0.867
	K, mg/dl	30.38[c]	25.07[d]	31.03[d]	29.82	30.32	27.42	27.74	2.081
	P, mg/dl	6.71	6.87	7.22	6.34	7.35	6.99	7.04	0.595
	Cu, ppm	8.99[c]	6.69[d]	9.37[c]	8.70	7.96	8.32	8.42	1.106
	Zn, ppm	7.83	8.42	8.99	8.27	9.02	8.26	8.12	1.049
	Se, ppm	0.018	0.022	0.017	0.023	0.018	0.018	0.017	0.004
	Urea-N, mg/dl	19.21[c]	17.73[cd]	15.16[d]	16.97	18.39	17.33	16.78	1.796
28	Ca, mg/dl	12.00	12.08	12.13	11.86	12.28	12.13	12.01	0.409
	Mg, mg/dl	2.87	2.80	2.86	2.85	2.90	2.89	2.72	0.096
	K, mg/dl	2.175[cd]	24.16[c]	20.52[d]	22.60	22.76	21.6	21.62	0.928
	P, mg/dl	7.04[cd]	6.50[c]	7.52[d]	6.71	7.08	7.40	6.89	0.550
	Cu, ppm	6.90	5.94	7.08	6.79	6.52	6.19	7.05	1.105
	Zn, ppm	9.98	10.23	10.48	10.25	10.05	10.38	10.23	0.578
	Se, ppm	0.018	0.020	0.022	0.024	0.020	0.019	0.016	0.004
	Urea-N, mg/dl	16.57[c]	16.28[c]	13.88[d]	14.20[e]	17.27[f]	15.55[ef]	15.29[ef]	1.204
42	Ca, mg/dl	11.46	12.12	11.25	11.24	11.30	11.76	12.14	0.622
	Mg, mg/dl	2.30	2.37	2.24	2.21	2.24	2.39	2.38	0.138
	K, mg/dl	26.81[c]	26.24[cd]	25.24[d]	26.25	26.21	25.69	26.25	0.953
	P, mg/dl	8.58[c]	7.52[d]	8.15[cd]	7.97	8.11	8.20	8.04	0.436
	Cu, ppm	8.53	8.82	8.28	8.80	9.01	8.05	8.31	0.933
	Zn, ppm	9.02	9.13	9.42	9.08	9.62	9.50	8.57	0.575
	Se, ppm	0.024[c]	0.022[c]	0.007[d]	0.020	0.019	0.015	0.017	0.003
	Urea-N, mg/dl	16.27[c]	15.76[c]	13.72[d]	14.07[e]	15.49[ef]	16.05[f]	15.39[ef]	0.900

[a] Soy hulls.

[b] Soybean meal, 44% CP, solvent extracted.

[c,d] Means within a row with different superscripts are different ($P < 0.05$).

[e,f] Means within a row with different superscripts are different ($P < 0.05$).

On d 7, steers supplemented with soy hulls + SBM had higher ($P < 0.05$) serum Ca concentrations than steers supplemented with corn + SBM. Unsupplemented steers were intermediate. On d 14, steers fed soy hulls + SBM had higher ($P < 0.05$) serum Ca and Mg concentrations than steers supplemented with corn + SBM. Unsupplemented steers were intermediate. On d 14, steers supplemented with soy hulls+ SBM had lower ($P < 0.05$) serum Cu concentrations than unsupplemented steers or steers supplemented with corn + SBM. On d 28, steers supplemented with soy hulls + SBM had higher ($P < 0.05$) serum K concentrations than unsupplemented steers or steers supplemented with corn + SBM. Corn + SBM supplemented steers had higher ($P < 0.05$) serum P concentrations on d 28 than steers supplemented with soy hulls + SBM. Unsupplemented steers were intermediate. On d 42, unsupplemented steers had higher ($P < 0.05$) serum K concentrations that steers supplemented with corn + SBM. On d 42, unsupplemented steers had higher ($P < 0.05$) serum P concentrations than steers supplemented with soy hulls + SBM. No differences were seen in blood Se concentrations on any day due to previous pasture treatment. On d 0 no differences were detected in blood Se due to supplement. On d 7, steers supplemented with soy hulls + SBM had higher ($P < 0.05$) blood Se than steers supplemented with corn + SBM. No differences were detected in blood Se concentrations on d 14 or d 28 due to supplement treatment. On d 42, unsupplemented steers and those supplemented with soy hulls + SBM had higher ($P < 0.05$) blood Se concentrations than steers supplemented with corn + SBM.

Serum Urea-N Concentrations. Serum urea-N (SUN) concentration data are presented in Table 15. No differences were detected across treatments on d 0. On d 7, unsupplemented steers had higher ($P < 0.05$) SUN concentrations than steers supplemented with corn + SBM. Steers supplemented with soy hulls + SBM were intermediate. Steers grazing the poultry litter applied pastures had higher ($P < 0.05$) SUN concentrations than steers grazing the control pastures. Steers grazing the poultry litter fed and inorganic fertilized pastures were intermediate. On d 14, unsupplemented steers had higher ($P < 0.05$) SUN concentrations than steers supplemented with corn + SBM. Steers supplemented with soy hulls + SBM were intermediate. No differences were observed due to previous pasture treatment on d 14. On d 28, unsupplemented steers and steers supplemented with soy hulls + SBM had higher ($P < 0.05$) SUN concentrations than steers supplemented with corn + SBM. Steers grazing the poultry litter fed pastures had higher ($P < 0.05$) SUN concentrations than steers grazing the control pastures. Steers grazing the poultry litter applied and inorganic fertilized pastures were intermediate. On d 42, unsupplemented steers and steers supplemented with SH + SBM had higher ($P < 0.05$) SUN concentrations than steers supplemented with corn + SBM. Steers grazing poultry litter applied pastures had higher ($P < 0.05$) SUN concentrations than steers grazing control pastures. Steers grazing poultry litter fed and inorganic fertilized pastures were intermediate.

Pasture Study 2 –Heifer Development (SVAREC)

Forage Mass and Composition. Forage mass and chemical composition data are presented in Tables 16 and forage mineral data are presented in Table 17. Wet weather prohibited taking forage mass measures on d 0 of the study. Forage mass did not differ among treatments. Forage CP did not decrease below 18% during the study and was highest on d 14 (23.51%). Generally, forage mass and CP decreased over the trial. Forage Ca, Mg, and P concentrations remained near constant over the trial. Forage concentrations of Zn decreased over the trial.

Table 16. Forage mass and chemical composition. Heifer Development.

		Pasture						
Day	Item, DM basis	1	2	3	4	5	6	SEM
0	Mass, kg/ha	--	--	--	--	--	--	
	Ash, %	9.01^{abc}	8.86^{bc}	9.49^{a}	7.78^{d}	9.09^{ab}	8.57^{c}	0.090
	CP, %	19.72^{a}	21.17^{b}	23.72^{c}	20.99^{d}	23.00^{e}	23.27^{f}	0.0002
	NDF, %	55.12^{ab}	56.26^{b}	54.62^{a}	58.00^{c}	53.92^{a}	56.28^{b}	0.248
	ADF, %	30.01	27.51	26.56	29.22	27.77	28.11	1.205
	Cellulose, %	18.06^{a}	19.59^{ab}	35.59^{cd}	44.58^{d}	30.57^{bc}	32.02^{c}	2.151
	Lignin, %	0.46	0.45	0.48	0.47	0.27	0.42	0.075
7	Mass, kg/ha	1157	11147	8917	8741	13259	12789	
	Ash, %	9.56^{a}	8.67^{ab}	9.69^{a}	8.32^{b}	8.17^{b}	8.98^{ab}	0.196
	CP, %	20.46^{a}	22.66^{b}	20.61^{c}	18.97^{d}	22.00^{e}	20.0^{8f}	0.001
	NDF, %	52.21^{a}	51.28^{a}	54.45^{b}	52.18^{a}	51.67^{a}	50.44^{a}	0.379
	ADF, %	25.16	29.17	26.41	25.61	25.66	24.42	1.641
	Cellulose, %	49.88	15.08	24.68	36.35	28.33	27.28	7.086
	Lignin, %	0.39	0.47	0.36	0.33	0.34	0.35	0.064
14	Mass, kg/ha	10267	9915	9269	11499	8741	9504	
	Ash, %	10.74^{a}	9.33^{b}	10.06^{c}	9.46^{c}	9.22^{c}	9.47^{c}	0.053
	CP, %	23.67^{a}	24.38^{b}	22.77^{c}	22.63^{d}	24.32^{e}	23.30^{f}	0.001
	NDF, %	51.99^{a}	50.62^{a}	51.72^{a}	53.92^{b}	51.52^{a}	53.90^{b}	0.305
	ADF, %	25.60^{a}	24.68^{a}	25.71^{a}	31.59^{b}	25.29^{a}	26.29^{a}	0.786
	Cellulose, %	37.61^{a}	19.06^{b}	27.77^{ab}	32.06^{ab}	25.61^{ab}	37.06^{a}	3.099
	Lignin, %	0.47	0.41	0.44	0.37	0.47	0.47	0.022
28	Mass, kg/ha	9328	8155	5984	6688	10619	10795	
	Ash, %	10.31^{a}	9.42^{b}	9.72b	8.39^{c}	8.26^{c}	8.02^{c}	0.095
	CP, %	20.65^{a}	19.86^{b}	19.11^{c}	19.00^{d}	20.82^{e}	19.19^{f}	0.002
	NDF, %	55.32^{a}	55.55^{a}	55.64^{ab}	$56.81b^{c}$	56.38^{abc}	57.09^{c}	0.216
	ADF, %	25.38	26.29	27.38	27.03	27.08	27.30	0.467
	Cellulose, %	31.07	30.44	34.82	35.04	27.46	32.88	3.139
	Lignin, %	0.49	0.51	1.46	0.57	0.35	0.57	0.344
42	Mass, kg/ha	8037	7685	4752	8565	8565	6218	
	Ash, %	11.16^{a}	8.75^{b}	9.10^{b}	9.07^{b}	8.54^{b}	10.17^{c}	0.129
	CP, %	19349^{a}	16.37^{b}	16.69^{c}	18.61^{d}	20.29^{e}	17.19^{f}	0.002
	NDF, %	49.57^{a}	49.68^{a}	51.88^{b}	46.34^{c}	48.74^{a}	49.81^{a}	0.348
	ADF, %	24.49	24.52	25.79	22.62	25.20	25.02	0.642
	Cellulose, %	32.84^{a}	22.64^{bc}	27.16^{ab}	17.05^{b}	26.05^{ab}	31.93^{a}	2.381
	Lignin, %	0.95^{a}	0.44^{bc}	0.59^{abc}	0.34^{c}	0.49^{bc}	0.85^{ab}	0.078

[a,b,c,d,e,f] Means within rows with different superscripts are different ($P < 0.05$).

Table 17. Forage mineral composition. Heifer Development.

		Pasture						
Day	Item, DM basis	1	2	3	4	5	6	SEM
0	Ca, %	0.07^{ab}	0.69^{a}	0.75^{bc}	0.79^{c}	0.76^{c}	0.69^{a}	0.010
	Mg, %	0.41^{a}	0.41^{a}	0.38^{b}	0.40^{ab}	0.38^{b}	0.32^{c}	0.003
	P, %	0.33^{ab}	0.36^{a}	0.36^{a}	0.27^{c}	3.33^{ab}	0.32^{b}	0.006
	K, %	3.19^{ab}	3.34^{ab}	3.58^{a}	2.41^{c}	0.30^{bc}	3.02^{b}	0.072
	Cu, ppm	5.53^{ab}	5.83^{a}	6.05^{a}	5.05^{b}	6.00^{a}	5.70^{a}	0.107
	Zn, ppm	22.58^{a}	27.40^{b}	25.03^{ab}	23.28^{ab}	26.58^{ab}	27.00^{ab}	0.802
	Se, ppm	0.04	0.02	0.04	0.06	0.06	0.05	0.014
7	Ca, %	0.75^{a}	0.73^{a}	0.66^{b}	0.76^{a}	0.74^{a}	0.71^{ab}	0.010
	Mg, %	0.45^{a}	0.46^{a}	0.37^{bc}	0.43^{ab}	0.36^{c}	0.36^{c}	0.011
	P, %	0.38	0.35^{ab}	0.35^{ab}	0.31^{bc}	0.28^{c}	0.30^{c}	0.007
	K, %	3.84	3.39	3.66	3.25	3.18	3.37	0.121
	Cu, ppm	5.50	5.10	5.03	4.90	5.68	5.23	0.228
	Zn, ppm	23.93	22.65	20.58	20.80	20.03	20.43	1.283
	Se, ppm	0.02^{ab}	0.03^{bc}	0.02^{ab}	0.05^{c}	0.03^{bc}	0.01^{a}	0.004
14	Ca, %	0.72^{a}	0.79^{ac}	0.75^{ab}	0.86^{c}	0.76^{ab}	0.74^{ab}	0.012
	Mg, %	0.44^{a}	0.41^{ab}	0.39^{b}	0.42^{ab}	0.42^{ab}	0.35^{c}	0.007
	P, %	0.42^{a}	0.36^{bc}	0.38^{ab}	0.37^{b}	0.33^{c}	0.36^{bc}	0.006
	K, %	4.50^{a}	3.49^{c}	3.80^{bc}	3.47^{c}	3.92^{b}	3.66^{bc}	0.071
	Cu, ppm	5.63^{a}	3.60^{b}	3.70^{b}	3.95^{b}	4.30^{ab}	4.28^{ab}	0.277
	Zn, ppm	19.13	16.23	15.25	14.73	16.18	18.10	1.058
	Se, ppm	0.02^{ab}	0.04^{a}	0.01^{b}	0.05^{a}	0.04^{a}	0.03^{ab}	0.005
28	Ca, %	0.82^{a}	0.72^{ab}	0.68^{b}	0.76^{ab}	0.72^{ab}	0.76^{ab}	0.024
	Mg, %	0.43^{a}	0.39^{ab}	0.35^{bc}	0.40^{ab}	0.35^{bc}	0.32^{c}	0.012
	P, %	0.39^{a}	0.32^{b}	0.33^{b}	0.28^{c}	0.27^{c}	0.24^{c}	0.006
	K, %	3.96^{a}	2.93^{b}	3.33^{ab}	2.70^{b}	3.17^{b}	2.67^{b}	0.125
	Cu, ppm	5.45	6.05	5.90	5.15	5.68	5.18	0.195
	Zn, ppm	12.03^{a}	16.03^{ab}	17.45^{ab}	16.63^{ab}	20.38^{b}	20.75^{b}	1.073
	Se, ppm	0.01	0.06	0.03	0.04	0.03	0.01	0.011
42	Ca, %	0.71^{a}	0.78^{b}	0.67^{a}	0.76^{b}	0.70^{a}	0.68^{a}	0.009
	Mg, %	0.40^{a}	0.37^{ab}	0.33^{c}	0.36^{b}	0.33^{c}	0.29^{d}	0.005
	P, %	0.36^{a}	0.29^{bc}	0.27^{c}	0.29^{bc}	0.29^{bc}	0.31^{b}	0.005
	K, %	3.57^{a}	3.04^{b}	3.07^{b}	3.05^{b}	3.23^{b}	3.16^{b}	0.052
	Cu, ppm	5.26^{a}	4.23^{b}	4.13^{b}	4.03^{b}	4.38^{b}	4.83^{ab}	0.170
	Zn, ppm	18.28^{a}	17.05^{ab}	15.40^{abc}	12.20^{c}	11.85^{c}	13.33^{bc}	0.724
	Se, ppm	0.01	0.05	0.04	0.05	0.04	0.05	0.012

^{a,b,c,d} Means within rows with different superscripts are different ($P < 0.05$).

Performance. Performance data are presented in Table 18 and heifer weights are shown in Figure 3. Heifers supplemented with soy hulls + SBM at 0.5% BW had heavier ($P < 0.05$) initial weights than heifers supplemented with corn gluten feed + soy hulls at 0.5% BW. This effect was random, as heifers were blocked by pre-weaning weight. All heifers lost weight from d 0 to d 7. By d 14, heifers supplemented with soy hulls + SBM at 0.5% BW had higher ($P < 0.05$) cumulative daily gains than heifers supplemented with corn gluten feed + soy hulls fed at 0.5% BW. Heifers supplemented with corn gluten feed + soy hulls at 1.0% BW were intermediate. No differences were observed in cumulative gains on d 28 or d 42. Average supplement intake was similar for heifers supplemented at 0.5% BW and higher ($P < 0.05$) for heifers supplemented at 1.0% BW. Gain:supplement efficiency was similar for all three supplement types, although heifers supplemented with soy hulls + SBM at 0.5% BW had numerically greater supplement efficiency.

Rectal Temperatures, Morbidity Scores and Treatments. No differences in rectal temperatures were detected across all treatments for the duration of the study (Table 19). Morbidity scores are reported as a weekly average. No differences were detected in morbidity scores across treatments. The greatest number of animals was treated during wk 2. Twenty-eight heifers total were treated for illness. Nine were treated more than once. No animals were treated for a morbidity score higher than 3. All animals were treated based on elevated temperatures on sampling days.

Blood Serum Mineral Concentrations. Serum mineral concentration data are presented in Table 20. No differences were detected in serum mineral concentrations except Se across all treatments on any sampling day. All values are in normal range. There were no differences in

Table 18. Effects of supplementation on performance of grazing heifers. Heifer development.

	16% CP supplement			
	CGF[a] + SH[b]		SH[b] + SBM[c]	
Item	0.5% BW	1.0% BW	0.5% BW	SEM
	---------------------------kg----------------------------			
Initial weight	236.9[d]	238.1[de]	257.5[e]	5.93
Cumulative ADG				
Day 7	-1.20	-0.60	-0.09	0.375
Day 14	-0.47[d]	-0.09[de]	0.51[e]	0.208
Day 28	0.44	0.51	0.66	0.120
Day 42	0.61	0.78	0.83	0.084
Average intake[f]	0.93[d]	1.77[e]	1.07[d]	0.967
Gain:supplement DM	0.66	0.44	0.77	0.092

[a] Corn gluten feed.

[b] Soy hulls.

[c] Soybean meal, 44% CP, solvent extracted.

[d,e] Means within rows with different superscripts are different ($P < 0.05$).

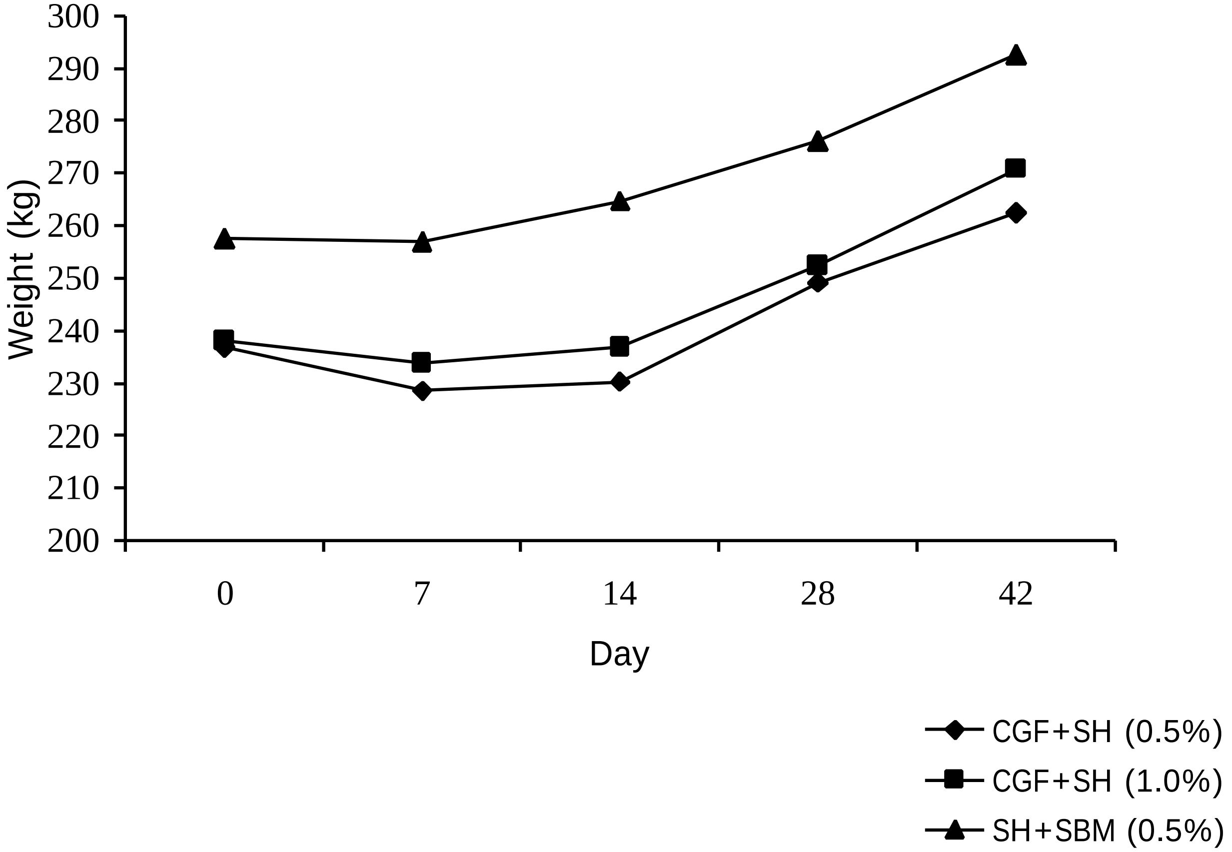

Figure 3. Effect of supplement on weights of heifers grazing stockpiled pasture. Heifer Development.

Table 19. Effects of supplementation on rectal temperatures, morbidity and treatment of grazing heifers. Heifer development.

	15% CP supplement			
	CGF[a] + SH[b]		SH[b] + SBM[c]	
Item	0.5% BW	1.0% BW	0.5% BW	SEM
Rectal temperatures[d]				
Day 0	39.68	39.91	39.72	0.120
Day 7	40.26	40.37	39.96	0.214
Day 14	39.44	39.68	39.45	0.092
Day 28	39.59	40.06	39.55	0.102
Day 42	39.54	39.74	39.54	0.096
Morbidity[e]				
Day 0	1.00	1.00	1.00	0.000
Day 1-7	1.09	1.04	1.00	0.036
Day 8-14	1.05	1.07	1.01	0.029
Day 15-28	1.00	1.00	1.00	0.000
Day 29-42	1.00	1.00	1.00	0.000
Treated[f]				
Day 0	--	--	--	
Day 1-7	1	--	--	
Day 8-14	8	11	9	
Day 15-28	1	5	1	
Day 29-42	--	2	--	

[a] Corn gluten feed.
[b] Soy hulls.
[c] Soybean meal, 44% CP, solvent extracted.
[d] Degrees Celsius
[e] Based on a subjective scoring system (1 = healthy, 5 = moribund).
[f] Number of animals treated.

Table 20. Effects of supplementation on serum profiles of grazing heifers. Heifer development.

		15% CP supplement			
		CGF[a] + SH[b]		SH[b] + SBM[c]	
Day	Item	0.5% BW	1.0% BW	0.5% BW	SEM
0	Ca, mg/dl	10.89	10.94	10.87	0.175
	Mg, mg/dl	1.96	1.96	1.89	0.098
	K, mg/dl	33.23	31.37	31.34	1.332
	P, mg/dl	6.39	6.53	6.38	0.285
	Cu, ppm	6.95	7.63	8.22	0.418
	Zn, ppm	9.48	10.39	9.35	0.418
	Se, ppm	0.042	0.042	0.050	0.004
	Urea-N, mg/dl	12.46	13.42	11.71	0.888
7	Ca, mg/dl	11.29	12.13	12.14	0.684
	Mg, mg/dl	2.15	2.36	2.25	0.113
	K, mg/dl	25.25	25.65	25.92	1.002
	P, mg/dl	6.82	6.79	5.98	0.348
	Cu, ppm	7.39	7.80	8.74	0.488
	Zn, ppm	8.00	8.60	8.40	0.563
	Se, ppm	0.044[d]	0.052[de]	0.062[e]	0.004
	Urea-N, mg/dl	29.01	18.79	22.51	5.043
14	Ca, mg/dl	12.07	12.38	12.00	0.468
	Mg, mg/dl	2.30	2.50	2.39	0.084
	K, mg/dl	28.41	26.33	27.59	1.008
	P, mg/dl	7.37	7.36	6.70	0.266
	Cu, ppm	5.98	5.32	5.87	0.732
	Zn, ppm	11.25	11.05	11.60	0.534
	Se, ppm	0.056	0.050	0.070	0.006
	Urea-N, mg/dl	21.47[d]	19.31[e]	21.23[de]	0.615
28	Ca, mg/dl	12.02	11.54	11.84	0.336
	Mg, mg/dl	2.53	2.25	2.45	0.167
	K, mg/dl	30.52	30.64	29.87	0.992
	P, mg/dl	7.36	7.58	6.66	0.300
	Cu, ppm	8.25	8.42	8.23	0.287
	Zn, ppm	11.84	12.57	11.69	0.424
	Se, ppm	0.069	0.064	0.068	0.006
	Urea-N, mg/dl	19.19[d]	18.82[d]	22.58[e]	0.601
42	Ca, mg/dl	12.08	12.03	11.90	0.157
	Mg, mg/dl	2.41	2.33	2.28	0.089
	K, mg/dl	28.08	25.98	28.28	1.008
	P, mg/dl	6.91	7.23	6.17	0.340
	Cu, ppm	4.38	4.55	4.88	0.341
	Zn, ppm	11.20	11.76	11.40	0.410
	Se, ppm	0.065	0.067	0.064	0.003
	Urea-N, mg/dl	15.86[d]	16.46[de]	17.62[e]	0.448

[a] Corn gluten feed.

[b] Soy hulls.

[c] Soybean meal, 44% CP, solvent extracted.

[d,e] Means within rows with different superscripts are different ($P < 0.05$).

initial blood Se concentrations across treatments. On d 7, heifers supplemented with soy hulls + SBM had higher ($P < 0.05$) blood Se concentrations than heifers supplemented with corn gluten feed + soy hulls fed at 0.5% BW. No differences were observed on d 14, 28, or 42 due to supplement treatment.

Serum Urea-N Concentrations. Serum urea-N (SUN) concentration data are presented in Table 20. No differences were detected between all treatments on d 0 and d 7. On d 14, heifers supplemented with corn gluten feed + soy hulls at 0.5% BW had higher ($P < 0.05$) SUN concentrations than heifers supplemented with corn gluten feed + soy hulls at 1.0% BW. Heifers supplemented with soy hulls + SBM at 0.5% BW were intermediate. On d 28, heifers supplemented with soy hulls + SBM at 0.5% BW had higher ($P < 0.05$) SUN concentrations than heifers supplemented with corn gluten feed + soy hulls at either 0.5% BW or 1.0% BW. On d 42, heifers supplemented with soy hulls + SBM at 0.5% BW had higher ($P < 0.05$) SUN concentrations than heifers supplemented with corn gluten feed + soy hulls fed at 0.5% BW. Heifers supplemented with corn gluten feed + soy hulls fed at 1.0% BW were intermediate.

Pasture Study 3 –Big Meadow (SVAREC)

Forage Mass and Composition. The forage chemical composition and mass data are presented in Table 21 and forage mineral composition data is presented in table 22. Wet weather prohibited taking forage mass measures on d 0 of the study. After d 14, there was not sufficient forage available for either grazing or measuring mass. Hay was fed to steers after d 14. In general, forage mass and CP decreased over time. Mineral content of the forage was similar on both sampling days. There were no significant differences between sampling days for any chemical composition data.

Table 21. Forage mass and chemical composition. Big Meadow.

		Pasture				
Day	Item, DM basis	1	2	3	4	SEM
0	Mass, kg/ha	--	--	--	--	
	Ash, %	9.69^{a}	8.92^{b}	8.30^{c}	9.79^{a}	0.034
	CP, %	24.12^{a}	22.82^{b}	22.65^{c}	27.68^{d}	0.000
	NDF, %	55.37^{ab}	53.88^{b}	53.61^{b}	56.19^{a}	0.354
	ADF, %	26.02	25.24	24.21	25.28	0.609
	Cellulose, %	35.93	33.08	26.43	32.24	3.877
	Lignin, %	0.21	0.13	0.07	0.22	0.05
7	Mass, kg/ha	3314	704	968	648	
	Ash, %	10.21^{a}	9.74^{c}	10.08^{ab}	9.95b^{c}	0.040
	CP, %	22.31^{a}	22.86^{b}	24.23^{c}	23.92^{d}	0.000
	NDF, %	56.16^{a}	50.04^{b}	49.71^{b}	52.05^{c}	0.151
	ADF, %	26.59^{a}	22.71^{b}	22.73^{b}	23.40^{b}	0.413
	Cellulose, %	48.94	37.41	42.60	27.58	9.197
	Lignin, %	0.34	0.32	0.22	0.30	0.059
14	Mass, kg/ha	821	909	176	616	
	Ash, %	9.34^{a}	9.21^{a}	8.74^{b}	9.32^{a}	0.037
	CP, %	19.15^{a}	18.90^{b}	19.87^{c}	19.39^{d}	0.000
	NDF, %	57.73^{a}	57.00^{a}	61.70^{b}	57.95^{a}	0.483
	ADF, %	27.54	27.21	28.99	27.99	0.495
	Cellulose, %	42.72^{ab}	40.55^{b}	5.08^{a}	38.90^{b}	2.407
	Lignin, %	0.43	0.47	0.51	0.199	0.157

^{a,b,c,d} Means within rows with different superscripts are different ($P < 0.05$).

Table 22. Forage mineral composition. Big Meadow.

		Pasture				
Day	Item, DM basis	1	2	3	4	SEM
0	Ca, %	0.57^{a}	0.50^{ab}	0.55^{ab}	0.46^{b}	0.017
	Mg, %	0.32	0.33	0.34	0.34	0.008
	P, %	0.39^{a}	0.39^{a}	0.31^{b}	0.39^{a}	0.012
	K, %	3.51^{a}	3.18^{ab}	2.82^{b}	3.66^{a}	0.087
	Cu, ppm	11.05^{a}	11.28^{a}	9.40^{b}	12.32^{a}	0.282
	Zn, ppm	4.60^{a}	4.23^{a}	3.08^{b}	3.44^{b}	0.107
	Se, ppm	0.03	0.03	0.03	0.02	0.005
7	Ca, %	0.56	0.50	0.51	0.48	0.016
	Mg, %	0.32^{a}	0.33^{ab}	0.33^{ab}	0.36^{b}	0.006
	P, %	0.40^{ab}	0.38^{a}	0.32^{c}	0.41^{b}	0.005
	K, %	3.52^{a}	3.19^{b}	3.54^{a}	3.81^{a}	0.051
	Cu, ppm	10.92	10.77	11.55	11.70	0.216
	Zn, ppm	4.04	3.54	3.53	3.79	0.131
	Se, ppm	0.02	0.02	0.03	0.02	0.005
14	Ca, %	0.53^{a}	0.50^{ab}	0.52^{a}	0.46^{b}	0.007
	Mg, %	0.32	0.32	0.29	0.30	0.011
	P, %	0.39^{ab}	0.37^{a}	0.28^{c}	0.42^{b}	0.007
	K, %	3.11^{a}	2.86^{b}	2.43^{c}	3.03^{a}	0.029
	Cu, ppm	11.25^{a}	10.17^{ab}	8.85^{b}	9.98^{ab}	0.246
	Zn, ppm	4.58^{a}	3.54^{bc}	3.18^{c}	4.10^{ab}	0.131
	Se, ppm	0.06^{a}	0.03^{b}	0.02^{b}	0.03^{b}	0.006

[a,b,c] Means within rows with different superscripts are different ($P < 0.05$).

Performance. Performance data are presented in Table 23 and steer weights are shown in Figure 4. Initial weights did not differ due to injection treatment. All steers had negative cumulative gains from d 0 to d 14. There were no differences in cumulative gain due to injection treatment on any days.

Rectal Temperatures, Morbidity Scores and Treatments. No differences in rectal temperatures were observed due to treatment for the duration of the study (Table 24). Morbidity scores are reported as weekly averages. There were no differences in morbidity scores across all treatments for the duration of the trial. The number of animals treated for illness did not differ with injection treatment. The greatest numbers of animals were treated from d 8 to d 14. Twenty steers were treated over the course of the study and three animals were treated more than once. No animals were treated for morbidity scores higher than 3. All animals were treated based on elevated temperatures on regular sampling days.

Blood Serum Mineral Concentrations. Serum mineral data are presented in Table 25. There were no differences in serum mineral concentrations across all treatments for d 0, 7, 14, and 28. On d 42, steers that did not receive a vitamin E or Se injection had higher ($P < 0.05$) serum Ca concentrations than steers receiving a Se injection. Steers receiving vitamin E and vitamin E + Se injections were intermediate. There were no differences in blood Se concentrations across all injection treatments for all days.

Serum Urea-N Concentrations. Serum urea-N (SUN) concentration data are presented in Table 25. There were no differences in SUN concentrations across all treatments on all sampling days.

Table 23. Effect of injection treatment on performance of steers grazing tall fescue pasture. Big Meadow.

Item	Injection treatment				SEM
	None	Selenium	Vitamin E	Selenium + Vitamin E	
	------------------------------kg--------------------------------				
Initial weight	247.4	251.6	260.3	257.0	7.704
Cumulative ADG					
Day 7	-1.47	-2.17	-1.65	-2.45	0.207
Day 14	-0.118	-0.384	-0.209	-0.389	0.207
Day 28	0.382	0.059	0.175	0.116	0.128
Day 42	0.220	0.020	0.098	0.077	0.102

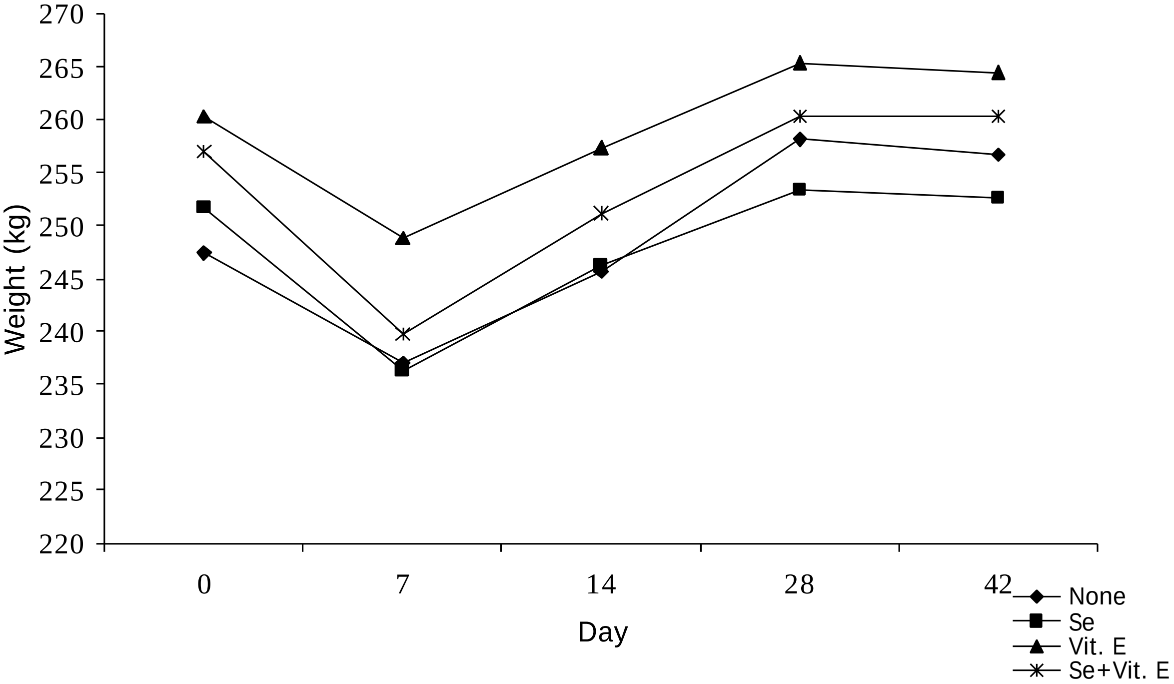

Figure 4. Effect of selenium and vitamin E injections on weights of steers. Big Meadow.

Table 24. Effect of injection treatment on rectal temperatures, morbidity and treatment of steers grazing tall fescue pasture. Big Meadow.

Item	Injection treatment				SEM
	None	Selenium	Vitamin E	Selenium + Vitamin E	
Rectal temperatures[a]					
Day 0	39.63	39.99	39.67	39.85	0.147
Day 7	39.55	39.62	39.51	39.63	0.163
Day 14	38.76	38.85	38.79	38.80	0.186
Day 28	39.91	39.70	39.76	39.82	0.138
Day 42	39.23	39.53	39.32	39.59	0.145
Morbidity[b]					
Day 0	1.00	1.00	1.00	1.00	0.000
Day 1-7	1.00	1.01	1.00	1.00	0.006
Day 8-14	1.00	1.00	1.01	1.01	0.008
Day 15-28	1.00	1.00	1.00	1.00	0.000
Day 29-42	1.00	1.00	1.00	1.00	0.000
Treated[c]					
Day 0	--	--	--	--	
Day 1-7	--	--	--	--	
Day 8-14	6	5	3	5	
Day 15-28	3	1	1	--	
Day 29-42	--	--	--	--	

[a] Degrees Celsius

[b] Based on a subjective scoring system (1 = healthy, 5 = moribund).

[c] Number of animals treated.

Table 25. Effect of injection treatment on serum mineral profiles of steers grazing tall fescue pasture. Big Meadow.

Day	Item	Injection treatment None	Selenium	Vitamin E	Selenium + Vitamin E	SEM
0	Ca, mg/dl	12.39	10.63	12.13	11.13	0.989
	Mg, mg/dl	2.37	2.09	2.39	2.08	0.201
	K, mg/dl	41.53	42.58	40.72	38.91	2.110
	P, mg/dl	6.31	6.90	7.23	6.79	0.287
	Cu, ppm	6.13	6.18	5.82	5.88	0.496
	Zn, ppm	8.72	8.63	9.01	9.23	0.546
	Se, ppm	0.036	0.039	0.042	0.039	0.003
	Urea-N, mg/dl	11.50	11.43	12.55	10.44	0.792
7	Ca, mg/dl	10.68	10.73	11.27	11.37	0.537
	Mg, mg/dl	2.12	2.16	2.27	2.18	0.094
	K, mg/dl	24.74	23.32	25.78	25.16	1.741
	P, mg/dl	6.54	7.05	7.29	6.53	0.264
	Cu, ppm	8.04	7.69	7.40	7.33	0.676
	Zn, ppm	7.02	6.43	7.15	6.69	0.615
	Se, ppm	0.039	0.033	0.037	0.035	0.003
	Urea-N, mg/dl	23.14	22.58	23.99	23.52	1.110
14	Ca, mg/dl	11.86	11.62	11.62	11.84	0.228
	Mg, mg/dl	2.35	2.38	2.28	2.38	0.065
	K, mg/dl	27.85	25.88	26.36	28.09	0.755
	P, mg/dl	7.72	7.72	7.69	7.82	0.270
	Cu, ppm	7.29	7.23	6.99	7.05	0.514
	Zn, ppm	7.17	6.83	7.44	7.37	0.367
	Se, ppm	0.030	0.027	0.031	0.029	0.002
	Urea-N, mg/dl	22.38	22.95	22.81	22.83	0.812
28	Ca, mg/dl	13.00	12.01	12.24	13.32	0.898
	Mg, mg/dl	2.55	1.92	2.21	2.34	0.311
	K, mg/dl	32.27	35.68	36.90	37.70	1.686
	P, mg/dl	7.71	7.39	8.02	7.96	0.259
	Cu, ppm	8.75	9.14	8.78	8.26	0.543
	Zn, ppm	8.56	8.39	9.75	8.89	0.540
	Se, ppm	0.029	0.028	0.042	0.029	0.005
	Urea-N, mg/dl	16.03	16.75	16.07	17.54	1.415
42	Ca, mg/dl	13.99[a]	11.17[b]	11.94[ab]	12.67[ab]	0.621
	Mg, mg/dl	2.66	2.10	2.27	2.76	0.247
	K, mg/dl	34.13	32.61	33.69	34.22	0.759
	P, mg/dl	7.83	7.71	7.62	7.91	0.262
	Cu, ppm	8.92	9.00	8.22	8.02	0.471
	Zn, ppm	7.97	7.55	7.99	8.94	0.801
	Se, ppm	0.047	0.041	0.051	0.044	0.004
	Urea-N, mg/dl	17.93	17.55	16.98	17.36	0.789

[a,b] Means within rows with different superscripts are different ($P < 0.05$).

Serum Alpha-Tocopherol Concentrations. Serum alpha-tocopherol concentration data are presented in Table 26. There were no differences in serum alpha-tocopherol concentrations across treatments on all sampling days.

Pasture Study 4 – Kentland

Forage Composition and Mass. Forage composition and mass data are presented in Tables 27 and forage mineral concentration data are presented in Table 28. On d 0, fescue pastures had more forage ($P < 0.05$) than fescue + alfalfa pastures. On d 0, CP was higher ($P < 0.05$) for the fescue + alfalfa pastures. On d 0 and d 7, fescue pastures had higher ($P < 0.05$) NDF and ADF values than fescue + alfalfa pastures. On d 14 fescue pastures had higher ($P < 0.05$) ash content than fescue + alfalfa pastures. On d 42, fescue pastures had higher ($P < 0.05$) NDF values than fescue + alfalfa pastures.

On d 0, fescue + alfalfa pastures had higher ($P < 0.05$) Ca concentrations than fescue pastures, but fescue pastures had higher ($P < 0.05$) Mg concentrations. On d 7, fescue + alfalfa pastures had higher Ca ($P < 0.05$) content than fescue pastures, while fescue pastures had higher ($P < 0.05$) K concentrations than the fescue + alfalfa pastures. Fescue + alfalfa pastures had higher ($P < 0.05$) P concentrations than fescue pastures. Fescue pastures had higher ($P < 0.05$) Se concentrations than fescue + alfalfa pastures. On d 14, fescue pastures had higher ($P < 0.05$) P concentrations than fescue + alfalfa pastures. On d 28, fescue + alfalfa pastures had higher ($P < 0.05$) Ca concentrations than fescue pastures.

Performance. Performance data are presented in Table 29 and steer weights are shown in Figure 5. There were no interactions between pasture type and injection treatment on any day. There were no differences in initial weight of all steers across treatments. All steers had

Table 26. Effect of injection treatment on alpha tocopherol concentrations of steers grazing tall fescue pasture. Big Meadow.

Day	Injection treatment				SEM
	None	Selenium	Vitamin E	Selenium + Vitamin E	
	------------------------------ng/?l------------------------------				
0	6.22	5.95	6.26	6.39	0.603
7	7.28	6.48	6.49	5.79	0.493
14	6.33	5.64	5.65	5.15	0.436
28	5.03	4.13	4.95	4.02	0.420
42	4.98	3.98	4.15	4.71	0.683

Table 27. Forage mass and composition of pasture type (tall fescue vs. tall fescue + alfalfa) for grazing steers. Kentland.

		Forage		
Day	Item	Fescue	Fescue + alfalfa	SEM
0	Mass, kg/ha	3075.95^{b}	2049.82^{c}	179.536
	Ash, %	11.20	10.84	0.332
	CP,%^{a}	21.11^{b}	24.33^{c}	0.834
	NDF, %^{a}	51.29^{b}	40.02^{c}	2.078
	ADF, %^{a}	25.84^{b}	22.95^{c}	0.642
	Cellulose, %^{a}	3.31	4.19	0.557
	Lignin, %^{a}	0.24	0.19	0.049
7	Ash, %	11.44	10.79	0.304
	CP,%^{a}	19.88	23.24	0.995
	NDF, %^{a}	54.54^{b}	41.73^{c}	2.099
	ADF, %^{a}	27.86^{b}	23.89^{c}	0.516
	Cellulose, %^{a}	3.19	3.83	0.413
	Lignin, %^{a}	0.16	0.13	0.029
14	Mass, kg/ha	1673.90	1793.32	243.554
	Ash, %	11.32^{b}	10.74^{c}	0.137
	CP,%^{a}	22.31	23.79	0.577
	NDF, %^{a}	42.11	39.99	1.158
	ADF, %^{a}	21.88	21.51	0.581
	Cellulose, %^{a}	1.94	2.31	0.468
	Lignin, %^{a}	0.29	0.26	0.019
28	Mass, kg/ha	1440.31	1339.80	164.657
	Ash, %	10.89	10.65	0.274
	CP,%^{a}	22.84	24.04	0.953
	NDF, %^{a}	43.69^{b}	40.09^{c}	0.898
	ADF, %^{a}	21.57	20.97	0.592
	Cellulose, %^{a}	1.92b	3.81c	0.419
	Lignin, %^{a}	0.17	0.18	0.034

[a] Dry matter basis.

[b,c] Means within a row with different superscripts are different ($P < 0.05$).

Table 28. Forage mineral profile of pasture type (tall fescue vs. tall fescue + alfalfa) for grazing steers. Kentland.

		Forage		
Day	Item	Fescue	Fescue + alfalfa	SEM
0	Ca, %	0.57^{b}	1.11^{c}	0.139
	Mg, %	0.59^{b}	0.52^{c}	0.028
	K, %	4.73	4.31	0.276
	P, %	0.44	0.45	0.011
	Cu, ppm	5.99	6.45	0.657
	Zn, ppm	23.46	20.25	3.088
	Se, ppm	0.20	0.18	0.018
7	Ca, %	0.52^{b}	1.09^{c}	0.137
	Mg, %	0.55	0.51	0.014
	K, %	4.88^{b}	4.21^{c}	0.159
	P, %	0.42^{b}	0.45^{c}	0.006
	Cu, ppm	5.33	6.49	0.629
	Zn, ppm	20.93	14.91	2.882
	Se, ppm	0.14^{b}	0.11^{c}	0.005
14	Ca, %	0.57	0.83	0.092
	Mg, %	0.46	0.49	0.042
	K, %	4.83	4.53	0.174
	P, %	0.46^{b}	0.39^{c}	0.010
	Cu, ppm	5.16	4.70	0.623
	Zn, ppm	21.15	18.44	2.380
	Se, ppm	0.20	0.16	0.026
28	Ca, %	0.54^{b}	0.88^{c}	0.091
	Mg, %	0.45	0.51	0.019
	K, %	4.72	4.26	0.192
	P, %	0.43	0.41	0.016
	Cu, ppm	4.39	4.15	0.676
	Zn, ppm	19.14	22.29	1.372
	Se, ppm	0.14	0.22	0.055

[a] Dry matter basis.

[b,c] Means within a row with different superscripts are different ($P < 0.05$).

Table 29. Effect of pasture type (tall fescue vs. tall fescue + alfalfa) and vitamin E and selenium injections on performance of grazing steers. Kentland.

	Forage		Injection			
Item	Fescue	Fescue + alfalfa	None	Vitamin E	Selenium	SEM
Initial weight	206.5	200.7	204.5	203.0	203.2	8.870
Cumulative ADG						
Day 7	-0.43	-0.11	-0.09	-0.19	-0.54	0.983
Day 14	1.64	1.49	1.69	1.43	1.56	0.734
Day 28	1.11	0.96	1.00	1.04	0.97	0.317
Day 42	0.97	1.03	0.99	1.04	0.97	0.125

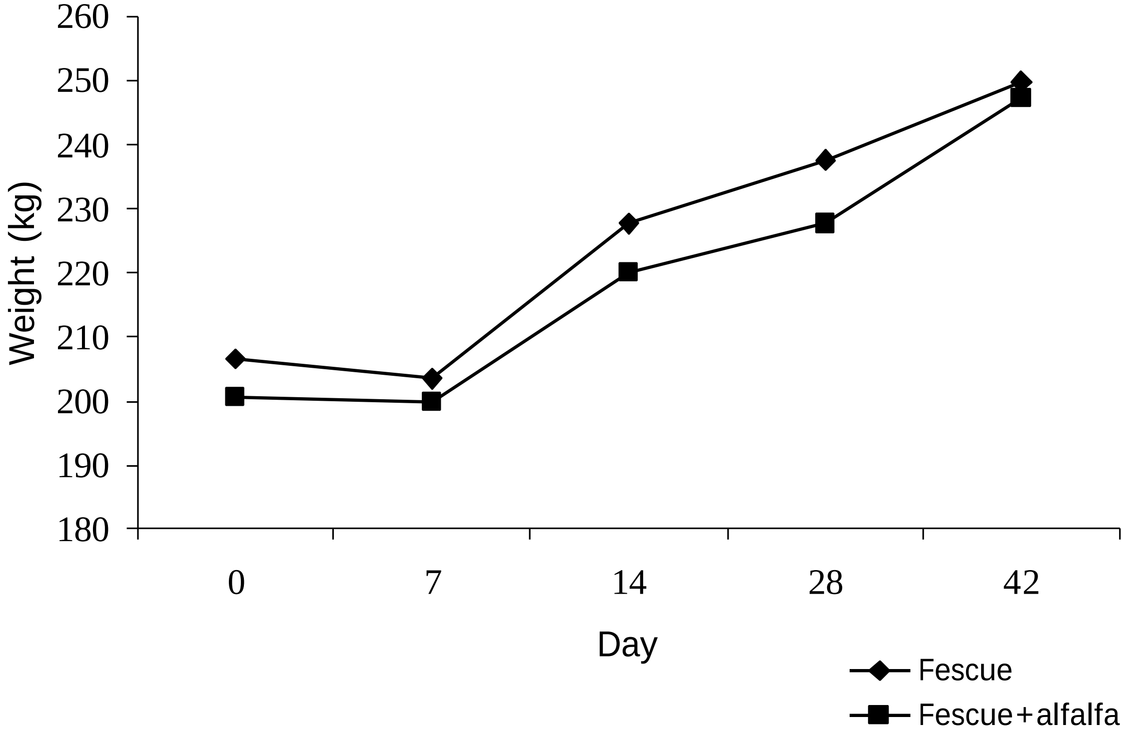

Figure 5. Effect of forage type (fescue vs. fescue+alfalfa) on steer weights. Kentland.

negative cumulative gains from d 0 to d 7. There were no differences in cumulative gains of all steers across treatments on all sampling days. Gains were very good for both kinds of pasture.

Rectal Temperatures, Morbidity Scores and Treatments. Rectal temperatures, morbidity scores, and treatment data are presented in Table 30. There were no differences in rectal temperatures across all treatments for the duration of the study. Morbidity scores are reported as weekly averages. There were no differences in morbidity scores across all treatments for the duration of the study. The highest number of calves were treated for illness during wk 2 and wk 3. A total of nine steers were treated for illness, and no animal was treated more than once. No steers were treated for morbidity scores higher than 3. All animals were treated for elevated temperatures on regular sampling days.

Serum Mineral Concentrations. Serum mineral concentration data are presented in Table 31. There were no differences in mineral concentration of steers based on pasture type (fescue vs. fescue + alfalfa) on d 0. On d 0, steers not receiving a vitamin E or Se injection had higher ($P < 0.05$) serum Zn concentrations than steers scheduled to receive Se injections. This effect was random as the animals had not been exposed to either the pastures or the injection treatments yet. On d 28, steers grazing fescue + alfalfa pastures had higher ($P < 0.05$) serum Mg concentrations than steers grazing fescue pastures. However, steers grazing fescue pastures had higher ($P < 0.05$) serum P concentrations than steers grazing fescue + alfalfa pastures. On d 0, steers scheduled to receive Se injections had higher ($P < 0.05$) blood Se concentrations than control steers. This significance was random, as steers had not yet been exposed to injection treatments. On d 7, 14, 28, and 42, steers given Se injection had higher ($P < 0.05$) blood Se concentrations than steers given no injection. On d 7, 28, and 42, steers given a Se injection had higher ($P < 0.05$) blood Se concentrations than steers given a vitamin E injection.

Table 30. Effect of pasture type (tall fescue vs. tall fescue + alfalfa) and vitamin E and selenium injections on rectal temperatures, morbidity and treatment of grazing steers. Kentland.

	Forage		Injection			
Item	Fescue	Fescue + alfalfa	None	Vitamin E	Selenium	SEM
Rectal temperatures[a]						
Day 0	39.68	39.91	39.68	39.78	39.93	0.170
Day 7	39.25	39.54	39.46	39.24	39.48	0.179
Day 14	39.26	39.45	39.22	39.35	39.50	0.213
Day 28	39.66	39.55	39.68	39.42	39.71	0.149
Day 42	39.73	39.74	39.68	39.61	39.91	0.128
Morbidity[b]						
Day 0	1.00	1.00	1.00	1.00	1.00	0.000
Day 1-7	1.00	1.01	1.01	1.00	1.00	0.007
Day 8-14	1.00	1.00	1.00	1.00	1.00	0.000
Day 15-28	1.00	1.01	1.00	1.00	1.01	0.006
Day 29-42	1.01	1.00	1.01	1.00	1.00	0.004
Treated[c]						
Day 0	--	--	--	--	--	
Day 1-7	--	--	--	--	--	
Day 8-14	--	4	2	1	1	
Day 15-28	--	2	1	--	1	
Day 29-42	1	2	1	--	2	

[a] Degrees Celsius

[b] Based on a subjective scoring system (1 = healthy, 5 = moribund).

[c] Number of animals treated.

Table 31. Effect of pasture type (tall fescue vs. tall fescue + alfalfa) and vitamin E and selenium injections on serum mineral profile of grazing steers. Kentland.

		Forage		Injection			
Day	Item	Fescue	Fescue + alfalfa	None	Vitamin E	Selenium	SEM
0	Ca, mg/dl	11.15	11.56	11.12	11.78	11.16	0.643
	Mg, mg/dl	2.35	2.38	2.25	2.51	2.34	0.182
	K, mg/dl	29.87	30.53	30.00	30.19	30.41	1.636
	P, mg/dl	7.03	7.03	6.62	7.37	7.09	0.341
	Cu, ppm	3.33	3.00	3.68	2.93	2.89	0.578
	Zn, ppm	6.87	6.65	7.47^{c}	7.34^{cd}	5.48^{d}	0.774
	Se, ppm	0.038	0.032	0.026^{a}	0.030^{ab}	0.048^{b}	0.008
	Urea-N, mg/dl	10.81	10.69	10.92	11.07	10.26	0.956
7	Ca, mg/dl	11.47	11.54	11.28	11.65	11.58	0.426
	Mg, mg/dl	2.37	2.18	2.22	2.33	2.27	0.154
	K, mg/dl	30.89	30.74	30.83	29.69	31.92	1.338
	P, mg/dl	6.53	6.21	6.10	6.56	6.44	0.369
	Cu, ppm	9.42	8.97	9.48	8.83	9.27	0.808
	Zn, ppm	9.09	8.54	8.46	9.20	8.79	0.625
	Se, ppm	0.026	0.028	0.021^{a}	0.021^{a}	0.040^{b}	0.004
	Urea-N, mg/dl	16.19^{a}	21.31^{b}	18.04	19.55	18.67	1.235
14	Ca, mg/dl	12.42	12.17	11.82	12.66	12.70	1.003
	Mg, mg/dl	2.58	2.67	2.42	2.63	2.83	0.261
	K, mg/dl	32.41	31.37	31.38	31.30	32.99	1.235
	P, mg/dl	6.88	6.99	6.79	6.97	7.05	0.377
	Cu, ppm	12.93	12.43	13.27	12.21	12.56	0.956
	Zn, ppm	11.31	10.94	10.98	11.27	11.12	0.852
	Se, ppm	0.032	0.037	0.029^{a}	0.033^{ab}	0.042^{b}	0.004
	Urea-N, mg/dl	15.13^{a}	19.28^{b}	17.58	16.68	17.36	1.220
28	Ca, mg/dl	11.72	12.20	11.99	11.73	12.15	0.422
	Mg, mg/dl	2.38^{a}	2.59^{b}	2.45	2.51	2.50	0.076
	K, mg/dl	33.58	33.76	33.90	32.40	34.70	1.734
	P, mg/dl	6.99^{a}	6.04^{b}	6.27	6.49	6.81	0.354
	Cu, ppm	8.84	8.98	9.31	8.98	8.44	0.864
	Zn, ppm	11.47	14.48	10.70	16.88	11.34	4.787
	Se, ppm	0.036	0.044	0.028^{a}	0.028^{a}	0.065^{b}	0.012
	Urea-N, mg/dl	12.26^{a}	14.41^{b}	13.63	12.92	13.47	0.593
42	Ca, mg/dl	12.14	11.12	12.01	11.85	11.03	0.887
	Mg, mg/dl	2.18	2.12	2.18	2.20	2.05	0.155
	K, mg/dl	24.53	24.99	24.22	24.38	25.67	1.101
	P, mg/dl	7.10	7.35	7.36	7.46	6.86	0.336
	Cu, ppm	8.71	8.86	9.05	8.61	8.68	0.722
	Zn, ppm	7.75	7.82	7.50	7.98	7.87	0.486
	Se, ppm	0.026^{c}	0.037^{d}	0.029^{a}	0.030^{a}	0.036^{b}	0.002
	Urea-N, mg/dl	11.99	12.71	12.34	11.98	12.74	0.655

[a,b] Means within a row with different superscripts are different ($P < 0.05$).

[c,d] Means within a row with different superscripts are different ($P < 0.05$).

Serum Urea-N Concentrations. Serum urea-N (SUN) concentration data are presented in Table 31. There were no differences in SUN concentrations across all treatments on d 0. On d 7, 14, and 28 steers grazing fescue + alfalfa pastures had higher ($P < 0.05$) SUN concentrations than steers grazing fescue pastures. There were no differences in SUN concentrations across all treatments on d 42.

Serum Alpha-Tocopherol Concentrations. Serum alpha-tocopherol concentration data are presented in Table 32. There were no differences in serum alpha-tocopherol concentrations across all treatments on d 0. On d 7 and d 14, steers grazing fescue pastures had higher ($P < 0.05$) serum alpha-tocopherol concentrations than steers grazing fescue + alfalfa pastures. There were no differences in serum alpha-tocopherol concentrations between steers grazing the two forage types on d 28 or d 42. There were no differences in serum alpha-tocopherol concentrations on any days due to injection treatment.

Table 32. Effect of pasture type (tall fescue vs. tall fescue + alfalfa) and vitamin E and selenium injections on alpha tocopherol concentrations of grazing steers. Kentland.

	Forage		Injection			
Day	Fescue	Fescue + Alfalfa	None	Vitamin E	Selenium	SEM
			ng/?l			
0	8.54	6.83	9.40	7.14	6.51	1.769
7	5.53^{a}	4.11^{b}	4.80	5.26	4.34	0.674
14	4.44^{a}	3.47^{b}	4.10	3.77	3.99	0.476
28	4.93	4.79	5.70	4.25	4.64	1.048
42	3.98	3.59	3.41	3.74	4.20	0.386

[a,b] Means within rows with different superscripts are different ($P < 0.05$).

Discussion

Based on earlier literature (Horn et al., 1995; Wahlberg et al., 1998; Austin, 2001), it was hypothesized that supplementation would increase daily gains and total weight compared to unsupplemented cattle. Morbidty and number of treatment days were observed closely in the present studies, as earlier work has shown potential adverse health effects of high levels of protein and energy (Lofgreen et al., 1980; Cole and Hutcheson, 1988; Galyean et al., 1999).

Forage Mass and Composition.

Over time, forage mass, CP, and ash concentrations decreased in the pasture trials. The decrease in forage mass can be attributed to animal consumption, as the forage was not growing during October through December. Forage mass values for pasture studies 2, 3, and 4 are similar to tall fescue forage mass values reported by Fritz and Collins (1991), whereas forage mass values for pasture study 1 are lower than Fritz and Collins reported. This may be due to drought in the summer months prior to the present study.

Over the course of the trials, as the forage matured the CP levels in the forage decreased and NDF, ADF, and cellulose levels increased. Decreasing CP over time in fall-stockpiled fescue has been reported by Fritz and Collins (1991) and Beconi et al. (1995). The CP levels in pasture study 1 were higher than those reported by Beconi et al. (1995). The elevated CP levels may also be due in part to the summer drought.

In pasture study 4, initial CP levels were higher in the fescue + alfalfa pastures. After wk 1, no differences were observed in CP levels. This disagrees with Seman et al. (1999) who reported higher CP levels in fescue + alfalfa pastures as compared to fescue pastures. Perhaps in the present study, the cattle selected the alfalfa forage over the fescue during the early part of the trial.

Supplementation of grazing animals may affect forage intake. Caton et al. (1988) concluded that supplementation to grazing cattle did not affect forage intake. On the contrary, Carey et al. (1993) concluded that unsupplemented steers had greater forage intake compared to grazing steers receiving an energy supplement. Austin (2001) determined that heifers supplemented at 1.0% BW consumed less hay than heifers supplemented at 0.5% BW, thus suggesting that substitution of supplement for forage may be occurring. In the present study, forage intake of animals on pasture was not measured, and concrete conclusions about forage intake and the effect of supplementation on forage intake, specifically, cannot be drawn from the data collected.

Performance.

In the drylot study, neither forage to concentrate ratio nor injection treatment had significant effects on animal daily gains, average intake, or feed efficiency. In pasture study 1, on d 7 unsupplemented steers had higher ($P < 0.05$) daily gains than steers supplemented with either soy hulls + SBM or corn + SBM. For the remainder of the study, there were no differences across supplement types in cumulative daily gains. In pasture study 2, heifers supplemented with soy hulls + SBM fed at 0.5% BW had higher cumulative gains on d 14 than heifers supplemented with corn gluten feed + soy hulls at either 0.5% BW or 1.0% BW. Gains were not different after d 14 of the study. In pasture study 3, there were no differences in steer performance across all injection treatments. Steers on all treatments had decreased cumulative gains, most likely due to a lack of available forage. After d 14 of the study, there was insufficient forage to graze, and steers were fed hay starting on d 14 for the remainder of the trial.

In recent studies, protein or energy supplementation to grazing animals has increased animal performance (Brown and Weigel, 1993; Fluharty and Loerch, 1995; Caton et al., 1997; Austin, 2001). In a study conducted by Wahlberg et al. (1998), calves that were backgrounded on pasture and fed a 14.9% CP corn + SBM supplement had similar ADG compared to steers in pasture study 1 of the present trials on the same treatment. Austin (2001) concluded that supplementing at 0.5% BW was more efficient than supplementing at 1.0% BW. He further concluded that supplementing steers on pasture at 0.5% BW produced higher ADG at d 28 than supplementing at 1.0% BW. This disagrees with pasture study 2 in the present trial. Heifers supplemented at 0.5% BW had similar gains to heifers supplemented at 1.0% BW. Efficiency was also similar between the two supplementation levels.

In the drylot study, steers were fed either a 40:60 forage to concentrate diet or a 70:30 forage to concentrate diet. There were no differences in cumulative daily gains, intake, or efficiency due to forage to concentrate ratio. Lofgreen et al. (1981), Fluharty et al. (1994), and Fluharty and Loerch (1996) studied the effects of energy vs. forage concentration in diets for receiving cattle. They concluded that animals fed a high-concentrate, high energy diet would consume less feed than animals consuming a diet with lower concentrate levels. They also concluded that feeding higher-concentrate diets at lower quantities led to increased feed efficiencies. Lofgreen et al. (1981) fed newly arrived calves a diet with 75% concentrate and found that calves did not eat significantly more than calves fed millet hay, but that the calves fed the concentrate gained weight more efficiently. In the present drylot trial, there were no differences in performance or efficiency between the 60% concentrate diet and 30% concentrate diet.

Fluharty and Loerch (1994) determined that diets high in energy were 8.7% more efficient than low energy diets for newly received steers. In 1996, Fluharty and Loerch conducted another study to determine the effects of receiving diet energy concentration on calf performance. Receiving diets contained 30, 40, 50, or 60% corn silage, DM basis, and were isonitrogenous (16% CP). They found no differences in ADG, DMI, or feed efficiency due to dietary energy during wk 1. During wk 3 and 4, there was a linear increase ($P < 0.02$) in DMI with increases in concentrate level. They concluded that the higher energy diet was important for stressed calves, such as those newly arrived at a feedlot.

Animals in pasture studies 2 and 3 lost weight during the first week of the trials. Decreased feed intake during this time period has been observed by Fluharty and Loerch (1995) and Lofgreen (1988).

Rectal Temperatures, Morbidity Scores and Treatments.

In general, morbidity in all trials tended to be elevated during wk 2 and wk 3, and then was less by wk 4 to 6. These morbidity trends are similar to those reported by Lofgreen (1981) and McCoy et al. (1998). Lofgreen (1981) detected a linear increase in morbidty of calves consuming greater levels of concentrate. Lofgreen fed total mixed diets with 25, 50, and 75% concentrate. In the present drylot study, no differences were observed in morbidity after d 7 due to diet treatment. The present study conditions were similar to those of Lofgreen. The pasture studies may not have had higher morbidity due to the concentrate being supplemented to pasture, rather than being fed as a total mixed ration.

Fluharty and Loerch (1996) found no differences in calf health and morbidity due to level of energy in the diet. The experiment conditions were similar to those of the drylot trial in the present study and the conclusions regarding morbidity are similar. McCoy et al. (1998) observed a decrease in morbidity with increasing metabolizable protein levels in receiving diets.

Calves located at the different sites varied considerably in terms of number of animals treated. Source of calves (purchased versus produced) also may have had an effect on animal morbidity and number of medical treatments required. The three groups of purchased calves were all processed upon arrival at their respective experiment locations. The two groups of produced calves were vaccinated similarly prior to weaning.

Blood Serum Mineral Concentrations.

Serum mineral concentrations vary greatly from experiment to experiment due to many factors. These factors include disease during shipping, transit or transport stress, previous calf supplementation, previous cow supplementation pre-partum, or infection (Galyean et al., 1999). They suggested that increased mobilization and excretion of some minerals is more likely to occur in stressed animals.

Orr et al. (1990) monitored serum mineral changes over time during an introduced bovine respiratory disease (BRD) infection and immediately following a infectious bovine rhinotracheitis (IBR) inoculation of healthy calves. Nine days after the BRDC, serum Cu increased ($P < 0.05$) and serum Zn decreased ($P < 0.05$). Serum Ca increased ($P < 0.05$) and serum P decreased ($P < 0.05$). Orr suggested that decreased feed intake may also contribute to the decreased quantities of some mineral in stressed or sick calves. Nockels at al. (1993) induced stress in feeder calves by dosing them with ACTH. This caused a decrease in serum Zn and an increase in serum Cu.

In the present trials, no consistent differences in serum minerals were detected across treatments. In these studies, the type of free-choice salt or mineral offered was dependent upon treatments for the trial. Animals in pasture studies receiving injections of vitamin E or Se, were offered plain white salt. Heifers in pasture study 2 were offered free-choice loose mineral. Diets for steers in drylot were mixed using trace mineral salt without additional Se added to it. The specific type of salt offered to each group was chosen in an effort to negate serum mineral increases due to salt intake as opposed to pasture or supplement intake. Austin (2001) observed mineral concentrations that changed over the 42 d trial time, but returned to initial values on d 42. This agrees with results of the present trials.

Serum Urea-N Concentrations.

In the present study, drylot steers fed 70:30 forage to concentrate diets had greater SUN concentrations on d 42 than steers consuming 40:60 forage to concentrate diets. This could be due to higher CP levels in the 70:30 diets and higher animal intake of the 70:30 diets (Preston et al., 1965). The steers fed the 70:30 diet consumed an average of 409 g CP/d compared to 326 g CP/d for the animals fed the 40:60 diet. In pasture study 1, unsupplemented steers had higher ($P < 0.05$) SUN concentrations than supplemented steers on d 7, 14, 28, and 42. In general, steers grazing pastures where poultry litter was either fed to previous cattle or poultry litter was applied directly to the fields had higher ($P < 0.05$) SUN concentrations than steers grazing control pastures or pastures fertilized inorganically. In pasture study 2, heifers supplemented with soy hulls + SBM at 0.5% BW or corn gluten feed + SBM at 0.5% BW had higher ($P < 0.05$) SUN concentrations than heifers supplemented with corn gluten feed + soy hulls at 1.0% BW on d 14 and d 28. On d 42, heifers supplemented with soy hulls + SBM at 0.5% BW had higher ($P < 0.05$) SUN concentrations than heifers supplemented with corn gluten feed + soy hulls at 0.5% BW. Serum urea-N concentrations were not different across all treatments on all days for pasture study 3. In pasture study 3, steers grazing fescue + alfalfa pastures had higher

($P < 0.05$) SUN concentrations on d 7, 14, and 28 compared to steers grazing fescue pastures. In general, the more N available in the forage, whether from poultry litter, inorganic fertilizer, alfalfa, or supplement, the higher the SUN concentrations in the animals.

Cole and Hutcheson (1988) studied the effects of different levels of dietary protein on plasma urea-N (PUN) concentrations in newly received calves. They concluded that protein concentration and PUN concentration were positively related, with higher SUN concentrations detected in calves fed higher levels of dietary protein. They also observed higher PUN concentrations after a period of fasting, such as shipping or marketing.

Blood Selenium Concentrations.

Dargatz (1996) studied blood Se concentrations on different cattle operations across the U.S in an effort to map out where Se was distributed. While Se concentrations in the forages and supplements fed during the present trials was generally low, the blood Se concentrations of the cattle on trial was adequate compared to other cattle in the southeastern region of the U.S.

While it is impossible to directly compare Se concentrations across trials, a few general observations may be made regarding the differences in Se concentrations in purchased calves versus those raised at the experiment station. In general, purchased calves (drylot study, pasture studies 1 and 4) tended to have lower blood Se concentrations as compared to experiment-station raised calves (pasture studies 2 and 3). This observation is similar to that of Austin (2001). Austin (2001) conducted similar trials at the same locations as the present studies and determined that purchased calves had lower blood Se concentrations and higher red blood cell GSH-Px concentrations than calves produced at SVAREC. The elevated GSH-Px concentrations are indicative of greater oxidative stress, perhaps from marketing and shipping stress. The lower Se concentrations in the purchased calves are similar to those of purchased calves in the present study. The blood Se concentrations in the experiment-station raised calves in the present study agree with those reported by Austin (2001) in similar trials. The lower blood Se values may result in increased susceptibility to disease, decreased immune function, or may be due to not consuming enough feedstuffs or forages with adequate Se concentrations. The purchased cattle had probably not been supplemented with Se prior to marketing and shipping. The cows at SVAREC are supplemented with Se in a loose mineral mix. Calves born to these cows (and subsequently put on study in the present trials), have numerically higher blood Se concentrations than purchased calves.

Serum Alpha-Tocopherol Concentrations.

Droke and Loerch (1989) supplemented vitamin E and selenium to determine the effects on performance, health, and humoral immune response. Their results agree with the present studies, in that vitamin E supplementation did not affect performance or number of animals treated for illness.

Pollock et al. (1994) studied the effects of dietary vitamin E on in vitro cellular immune responses in cattle. They found that animals supplemented with vitamin E had a greater immune response to inoculation than animals not given supplemental vitamin E. This is difficult to compare to the present trials, as no differences were observed in number of animals requiring medical treatment.

Nockels et al. (1996) compared the effects of ACTH induced stress on groups of heifers that were either vitamin E adequate or vitamin E deficient. The control diet contained 12.1 I.U. vitamin E per kg DMB and the vitamin E adequate group were fed 1000 I.U. per animal per day. The induction of stress decreased gains in both adequate and deficient heifers, although serum

Se increased in response to stress in the vitamin E adequate heifers. Stress did decrease the liver alpha-tocopherol content of both vitamin E adequate and vitamin E deficient heifers.

The results of the present study disagree with the conclusions of Gill et al. (1986). Gill et al. supplemented newly received feedlot cattle with 1600 I.U. vitamin E for 21 d followed by 7 d of supplementation at 800 I.U. vitamin E per animal and found a 23.2% increase in ADG and a 28.6% increase in gain:feed ratios. In the present study, vitamin E had no effect on performance or efficiency measures. This may be attributed to differences in feeding vitamin E as opposed to injecting it.

Implications

The results suggest that by-product feeds may be used instead of corn-based supplements in backgrounding programs, which may lower the cost. Supplementation at 1.0% BW tends to be less efficient than supplementation at 0.5% BW. Calves fed 40:60 forage to concentrate ratio diets performed similarly to calves fed 70:30 forage to concentrate ratio diets. The greater percentage of fiber in the 70:30 diet may be more beneficial to rumen health. Health status, apparent immune function, and serum mineral concentrations were similar among cattle receiving different supplements and diets. The majority of previous research conducted on supplementation and mineral levels for backgrounding diets has been conducted in feedlot environments, with relatively little research in pasture settings. Data from the present trials suggests that high quality pasture alone may be comparable in terms of animal performance to pasture with supplementation or drylot backgrounding. An appropriate backgrounding strategy will provide cow-calf producers and feedlot managers the ability to better transition calves from one stage of production to the next, with reduced detrimental impacts on immune function and performance.

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