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GRAZING COVER CROPS AS AN ALTERNATIVE TO FALLOW AND THE INTERACTION BETWEEN CORN PROCESSING METHOD AND CONDENSED DISTILLERS SOLUBLES

by

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GRAZING COVER CROPS AS AN ALTERNATIVE TO FALLOW AND THE INTERACTION BETWEEN CORN PROCESSING METHOD AND CONDENSED DISTILLERS SOLUBLES

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University of Nebraska, 2012

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Recently, producers in dryland wheat farming regions have made a shift from the typical winter wheat fallow rotation to a no-till system paired with cover crops. Cover crops have been shown to minimize these problems associated with the conventional fallow and possibly provide a source of forage. A 2-year grazing study was conducted to evaluate forage quality and utilization of cover crops (CC) planted to replace fallow in no-till wheat systems compared to crested wheatgrass pastures (CWP). Hand clipped and diet samples were greater in digestibility and CP for CC compared to CWP. The NDF and ADF content of the hand clipped and diet samples were less in CC compared to CWP. Forage production for CC was less in 2011 compared to CWP. In 2012, forage production was similar for CC compared to CWP. Forage utilization for both years was similar for CC and CWP.

An interaction exists when comparing corn processing methods and increased concentrations of wet distillers grains with solubles (WDGS). However, little research is

available studying the interaction between corn processing method and concentration of CDS. An experiment was conducted to test the interaction between condensed distillers solubles (CDS) and corn processing method in finishing diets. Interactions were observed between corn processing method and CDS concentration for final BW, ADG, and G:F. Within DRC based diets, final BW, ADG, and G:F increased quadratically with increasing concentration of CDS. The greatest final BW and ADG were observed at the 15% concentration of CDS. The greatest G:F was observed with the 30% concentration of CDS for DRC. For SFC based diets, linear improvements were observed in final BW and ADG as CDS concentration increased. A quadratic improvement in G:F was observed where greatest G:F was observed at the 30% CDS concentration. Replacing either DRC or SFC with CDS improved performance.

Key words: beef cattle, condensed distillers solubles, corn processing method, cover crops, grazing

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REVIEW OF THE LITERATURE I

Intergrating Cover Crops and Livestock

Introduction. With an increase in demand for cereal grains for food and fuel, and sustainability and conservation important, cover crops in farming systems are an attractive alternative to the conventional fallow in dryland wheat production. Fallow, which is a management option of not planting a crop during a growing season to benefit the next crop has been shown to conserve moisture, allow time for nutrient mineralization, and increase subsequent crop yields (Gardner et al., 1992). Early practices of fallow were known as black fallow. During the fallow phase cropland was tilled to control weeds. As soil erosion became a challenge, brown fallow replaced black fallow. In this system, the crop residue is left to inhibit erosion. Brown fallow, like black fallow, also poses some challenges. Leaching of nitrogen and applied herbicides while implementing this practice can be a risk. Collectively, the concept of replacing the fallow with cover crops could provide erosion control, supply nitrogen, use water efficiently, and maintain subsequent crop yields. Again there are challenges with cover crops as they are growing crops which use water and nutrients that can result in less for the following cash crop. With the concept of growing a crop in place of fallow, there are some opportunities to utilize the cover crops as forage for cattle.

Cover Crop Agronomic Uses. In typical wheat farming systems in the Great Plains a fallow period is included to accumulate soil moisture for the next wheat crop. Storing moisture during this fallow period minimizes the risk of failure for the next wheat crop. Problems that arise during this fallow period include poor use of precipitation, soil

erosion, and decreased soil organic matter (Black et al., 1981, Janzen, 1987, Campbell et al., 1990, Wienhold et al., 2006). An alternative to fallow with recent adoption in the Great plains is no-tillage with intensified crop rotations (Hansen et al., 2012). Intensified crop rotations, which include cover crops, may have advantages compared to fallow as it relates to water use and soil properties for following wheat crops.

The use of cover crops will be the focus of this review, which may consist of a variety of small grains, legumes, and brassica crops. These three types of crops each have factors that are suitable for use as a cover crop to replace fallow. Small grains and legumes provide biomass to decrease soil erosion and provide organic matter when decomposed. Hargrove (1986) demonstrated the ability of legumes and small grain crops to maintain or increase organic carbon available to the next crop from decomposition of crop residue. Increased root activity, which increases aggregation of soil is another suggested benefit of cover crops (Miller and Dick et al., 1995). Well aggregated soils increase the soils' storage capability of nutrients, water, and organic matter. These residues also help improve water infiltration and reduce losses due to evaporation (Fageria et al., 2005). Crop residues left in fields can increase soil moisture available to following crop compared to bare soil and stubble (Gallaher, 1977; Teasdale and Mohler, 1993).

Another important attribute from cover crops is the nitrogen fixed from the legumes. Nitrogen is generally the most limiting nutrient in crop production and cover crops can offer a source of biologically fixed nitrogen to offset fertilizer use. Haynes et al., (1993a) evaluated various legumes and their nitrogen balances (quantity fixed minus the quantity removed in the grain). All legumes were less than zero, but field peas

showed the greatest nitrogen balance. Rowland et al., (1994) showed increased wheat yields using field peas as a cover crop compared to continuous wheat. Greater nitrogen availability was partially responsible for the increased yields. Brassicas are included in cover crops for their ability to penetrate soil in a no-till system which serves as a source of natural tillage. Taproots from brassica species penetrate compacted soils to a greater extent than cereal grains (Chen and Weil, 2010). From these studies, using multiple species within cover crops may offer multiple benefits during one growing season for the next crop. Various species could be utilized depending on the situation, but for the purpose of this review, the discussion will be limited to oats, peas, and turnips.

Cover crops importance in Western Nebraska. In Western Nebraska, dryland wheat farming is prominent with fallow being a common practice. With the agronomic benefits and forage quality of cover crops described above, there is an opportunity for producers to enhance their operations. Along with the wheat farming, beef cattle production is another large part of the economy in Western Nebraska. Cows are numerous with many acres of range available and feedlots are also abundant in this area following the Platte River Valley. This large number of cows and stocker calves require large amounts of forage in this region. Cover crops may offer an additional source of forage in this area for cows and feeder cattle. The panhandle of Nebraska is located in a semi-arid region and precipitation can be below average for prolonged times. In drought years, forage yield can be reduced 20 to 50% (Holman et al., 2001). Reductions in stocking rates must accompany the reduced yields during drought in order to maintain stored energy and root systems for next year's growth. The additional forage from cover crops could be a viable option to maintain cow numbers while also reducing grazing pressure in range acres

during times of low forage yields. The reduced grazing pressure could benefit the range allowing storage of more nutrients for growth in normal years as well as drought years. Along with the extra forage, quality of cover crops is generally better than native grasses which may improve body condition in cows or performance with yearlings when grazed instead of range. Using cover crops as a source of forage may help offset the costs associated with utilizing them (Haag et al., 2003). Farmers could increase their returns per acre by selling the forage rather than having no income on those acres if they were in fallow. Also, there are benefits of grazing cattle on cropland with nutrient cycling which will be discussed later. Collectively, this integration of cattle and cropland may be a more sustainable approach with the benefits of cover crops for wheat farming and additional forage for cattle production in the panhandle.

Nutrient Cycling in Grazing Systems. Cover crops are planted with the goal of incorporating carbon and nitrogen from the organic matter back into the soil for future fertility. Cattle grazing cover crops in this system affect how much of these nutrients cycle back into the soil and must be considered. Simply looking at digestibility of the cover crops will give an indication of how much organic matter will go back to the soil. If digestibility of the forage is X, then 1-X is the indigestible portion. This indigestible portion is what will be excreted back to the soil. Most of what is consumed by ruminants are carbohydrates, therefore the excreta will contain large portions of carbon. When studying nitrogen cycling in a grazing system, complexities arise. Nitrogen retention in grazing situations has been reported between 5-25% of intake (Haynes and Williams, 1993b, Greenquist et al., 2011). Excess nitrogen consumed by the ruminant gets excreted mainly in the form of urea (NRC, 1996). The urea which is converted to NH_4 is highly

available for uptake by plants. Essentially, the rumen can speed up the cycling of nitrogen making it more available to the plants (Gardner and Faulker, 1991). However, volatilization and leaching of nitrogen are concerns as these represent losses to the system. Overall, grazing animals retain relatively small amounts of the available forage and careful management is needed to ensure cattle and crop needs are met when grazing cover crops.

Characterizing Oats for forage. Forage produced from oats (*avena sativa*) can be a good alternative to native grasses for stocker and cow calf operations. The NRC (1996) reports oat hay to have 53% TDN, 9.5% CP, and 63% NDF. Oat hay can vary in CP depending on the harvest date reported by Erickson et al. (1977; 14.9% at the fully headed stage to 10.8% when fully mature). They reported harvesting oat hay at the soft dough stage resulted in the greatest dry matter yield which was 785 kg/hectare. When compared to other cereal grain forages, wheat was lower in production per hectare compared to oats and barley, (*hordeum vulgare*) which were similar (Larson and Carter, 1970).

Oats can also be a viable source of pasture. Research has been conducted with cool season annual grasses compared oats, wheat, rye, ryegrass, and combinations of these species for grazing cattle (Beck et al., 2005). Steer ADG was similar when averaged across all three years for fall and winter grazing. However, differences were observed in spring ADG with the three year averages. When comparing the cereal grains, wheat had the highest ADG with oats and rye similar, but lower. One possible explanation for oats being lower than wheat could be due to a winter kill of the oats in year two. Other work conducted by Beck et al., (2006), evaluated inter-seeding oats, rye, or wheat into bermudagrass (*cynodon dactylon*) pastures. A tendency was observed

for oats to have lower ADG reported than wheat. Oltjen and Bolsen (1980) fed barley, wheat, oat, and corn silages to growing steers. Barley silage was similar to corn and wheat silage when comparing ADG. Oat silage was observed to have the lowest ADG.

Characterizing Peas for forage. Field peas used as forage offer another forage option with similar or better performance than native range. Field peas are grown for human consumption and marketed as split peas, but in areas where no markets exist, they can be used as livestock feed either with the grain, or forage. Also, varieties of field peas exist that are better suited for forage production. Weichenthal et al. (2008) reported quality values for peas of 75% IVDMD and 17.1% CP. In this study, barley, oats, triticale (*triticale hexaploide*), field pea, soybeans (*glycine max*), and vetch were all grown and harvested as hay. The greatest digestibilities were reported with soybeans and peas.

In other work with sheep grazing various grain legumes, including field peas, (Allden and Geytenbeek, 1977) observed BW gains in sheep to be highest in the first six weeks of grazing with field peas. Slightly lower digestibilities were observed with vetch, chick peas (*cicer arietinum*), and field beans. Thorlacius and Beacom (1981) investigated performance and feeding values of pea, field bean, corn, and oat silages in lambs. A growing study with these silages resulted in the highest ADG when field bean silage was fed compared to field pea silage which was slightly lower. Both of these silages produced gains statistically higher than corn and oat silage. A digestibility study showed similar organic matter (OM) digestibility between field beans (65.7%) and pea silage (73.6%) and both were higher than corn and oat silages.

Characterizing Turnips. Turnips (*brassica rapa*) are in the brassica genus of plants and are root crops that are harvested for their bulbs underneath the soil. They are commonly used in Europe as livestock feed and have a good nutrient quality and high yields (Bartholomew and Underwood. 2002). Grazing turnips provides the opportunity to extend the grazing season and provide acceptable amounts of TDN and CP to the livestock (McCartney et al., 2009).

Reid et al., (1994) studied grazing brassicas using sheep and made comparisons back to tall fescue (*festuca arundinacea*) or grass-clover pastures. The brassicas, a kale-(*brassica oleracea*) turnip mixture, and grasses were grazed in the middle of October to evaluate sheep performance and extending the grazing season. Data from the first experiment showed similar gains between tall fescue and turnips. Data from the next experiment showed a difference with turnips resulting in greater gains than tall fescue when grazed by sheep. One possible explanation for the low gains with turnips in experiment 1 is due to low fiber contents in the diets of these animals. In experiments 3 and 4, poor quality hay was provided ad libitum and greater ADG for sheep were recorded with the turnips compared to fescue or a grass clover mixture early in the trial. Over the whole grazing period however, gains were similar between the turnips and grass clover pastures. The poor quality hay was included as a means of providing fiber to slow down passage rates. The authors noted that the negative effect of hay later in the grazing period which resulted in similar performance with turnips and the control suggest that hay could be removed as it may dilute the energy of the turnips. However, the variability of ADG with brassicas warrants further investigation. Measurements of CP in the turnips for this trial found there to be 13.0% CP in the leaf portion of turnips and 7.1% CP in the

root portion. From these data, turnips offer a good source of CP, but may require long stemmed forage to slow passage rate. With gains being similar to control pastures, brassicas still do offer a source of forage for extending grazing seasons when utilized.

Protein Characteristics in Grazing Situations. Ruminants have the unique ability to harvest fiber and convert it to energy. This is possible through fermentation in the rumen from the microbial population. The rumen is a large fermentation vat which provides an optimal environment for the necessary anaerobic bacteria needed to digest the fiber. In order for these microbes to grow and divide, a source of nitrogen is required. This source of nitrogen comes from the diet as well as non-protein nitrogen (Church, 1988). The animal itself requires a source of protein as well which consists of protein from bacteria leaving the rumen as well as dietary protein that is not degraded in the rumen. The metabolizable protein (MP) system was developed in order to separate the protein needs for the microbial population and the animal (NRC, 1996).

Degradable intake protein (DIP) is defined as the protein that is digested in the rumen and used by the microbes. Undegradable intake protein (UIP) is not degraded in the rumen and digested in the small intestine which is made available to the animal. The sum of the UIP and protein from the microbes make up MP. The definition of MP is the protein that is absorbed through the intestine used by the animal. This allows for optimal use of protein for the microbes as well as the animal.

Determining DIP and UIP Requirements. Meeting protein requirements for cattle grazing low quality forages is critical for performance. Meeting DIP requirements will maximize microbial efficiency when grazing native range. Requirements of DIP for

cows grazing dormant native range during the winter months was determined by evaluating different levels of DIP supplementation using steep from the corn wet milling process (Hollingsworth-Jenkins et al., 1996). They predicted the DIP requirements for these cows and then fed levels above and below the requirement. In year one, they found no differences across levels which suggested the DIP requirement was met at the 50% level of the predicted value. In year two, they found that cows maintained between 29 and 65% levels, but lost condition at the required or higher levels. The data suggest that the DIP requirement is 7.1% of digestible OM.

Since lush forage protein is often highly rumen degradable, often a response from UIP supplementation will occur in cattle (MacDonald et al., 2007). During the summer months, Karges et al. (1992) found that yearlings grazing native range were not deficient in DIP based on grazing trials with DIP and UIP supplements. However, they did find that cattle responded to increased amounts of UIP when DIP requirements were met with increased ADG. This would suggest that the small amounts of available UIP from the forage in the control treatment may have limited cattle gains. An excellent strategy for supplying UIP is supplementation with distillers grains with solubles in forage diets (Loy et al., 2007, MacDonald et al., 2007, Griffin et al., 2009).

Protein with Cover Crops. Animal protein needs should be known and met in any feeding situations in order to maximize performance. The nutrient profiles of cover crops that were discussed earlier should provide an adequate amount of protein to the cattle especially when a legume is incorporated. The protein of grazed cover crops will most likely be ruminally degraded. With most of the protein being degraded in the rumen, cattle may have some deficiencies in MP supply when grazing cover crops. However,

with the amount of TDN available as discussed earlier in the manuscript, BCP flow to the small intestine will most likely be large enough to meet the animal's MP requirement. Bacterial crude protein flow synthesis and flow to the small intestine is dependent upon the amount of digestible carbohydrates in the diet and DIP (Karges, 1990). Cover crops should not be limiting with the amount of digestible carbohydrates that are available. Range, on the other hand, would possibly be limiting in digestible carbohydrates depending on quality and time of year. Also, similar to the cover crops, protein in range situations will most likely be degraded in the rumen as well which may cause a need for a source of UIP in the diet. The amount of digestible carbohydrates and bacterial crude protein help explain the greater gains seen with lush small grain pastures compared to native grasses typically available.

Winter Wheat Pasture Grazing. Another production system already in place comparable to grazing cover crops is the grazing of winter wheat in the southern plains. Inherently, there are differences between the two systems, for example, cover crops are not harvested as a crop, rather they are left to contribute their nutrients to the soil. Winter wheat, on the other hand, is planted in the fall in order to graze during the winter and early spring and still produce a wheat crop in the same growth period. In some circumstances, when the value of the cattle outweighs harvesting the wheat grain, producers will not harvest a crop and graze off the forage. Similarities between the two systems would include the use of cropland as pasture and similar forage types. Benefits of nutrient cycling would be similar between winter wheat and cover crop grazing. Also, the forage types and maturity would be similar across the two systems as wheat and oats are small grains and are in a vegetative growing state when grazed. Winter wheat grazing offers a valuable

resource that has made stocker enterprises possible in the southern plains and cover crops may fit as a forage source for this type of enterprise here in the Northern Plains. Producers who run stocker operations take advantage of less expensive cost of gains by putting weight on cattle using wheat pasture before sending cattle to feedlots. Cover crops, with their inherent quality, may provide similar performance as the winter wheat system and performance may be higher than cattle grazing native range.

Hersom et al., (2004) compared two different stocking rates on wheat pastures to grazing native winter range. Initially, steers grazing the wheat pastures were together for the first 45 days of grazing and then the high ADG group were allowed access to a different wheat pasture in which forage availability was higher than the low ADG group. These two scenarios were compared back to the cattle that were grazing winter range. The data suggest that grazing wheat results in greater ADG than native range and lower stocking densities while grazing wheat result in better performance. Imposed grazing treatments resulted in different initial BW at feedlot entry and HCW after the finishing period were greater for high ADG steers compared to low ADG, but similar to steers grazing native range in year one. In year two, HCW was similar across all three treatments. Gain and efficiency were similar in year one, but in year two, gain was highest for native range with efficiency being similar again. Cattle in year two were able to compensate for nutrient restrictions imposed before entering the feedlot. In a similar experiment, Choat et al., (2003) found that subsequent feed efficiency in the feedlot was greater for cattle that had grazed native range compared to steers grazing wheat. Similar to Hersom et al. (2004), HCW was greater for cattle grazing wheat compared to range.

Supplementation of DDGS on wheat pasture yielded an increase in final BW and ADG (Buttrey et al., 2012). In this trial, DDGS was compared to dry rolled corn (DRC) and a negative control with no supplementation. During the grazing period, ending BW and ADG were greater for the DDGS supplemented cattle. The DRC supplemented cattle were similar to the control cattle with no supplement. There was no effect due to supplementation on final BW or ADG on feedlot performance. There were differences in efficiency due to supplementation. Cattle supplemented DRC were more efficient in the feedlot than control cattle. Cattle supplemented with DDGS tended to be less efficient than DRC supplemented cattle. From a system persepective, the increase in gain from the grazing period due to DDGS did not follow into the finishing period as final BW were similar across different supplement treatments. These winter wheat grazing systems discussed above could serve as a proxy for prediction of forage quality and animal performance in a grazing cover crops system that contains large amounts of similar small grains.

Effects of Wheat Grazing on Crops. Grazing wheat too long into the spring has been shown to have detrimental effects on wheat yields. As wheat in the southern plains starts growing again in February due to the increase in temperature, cattle consuming the tiller and leaves will reduce the amount of photosynthetic area. This reduction of photosynthetic area is attributed to the loss of yields as plants. Trampling and wet conditions can also pose problems as cattle graze. Commonly, cattle are removed from wheat pasture in periods of wet weather to avoid such losses.

Winter and Thompson (1987) looked at the effects of cattle grazing wheat on grain yields with different durations of grazing. He reported that yields were similar in

the early February removal dates compared to the wheat not grazed. Grazing past early March resulted in declines of wheat yields. The authors hypothesized the reason for the reduced yields was less leaf area and biomass in the spring. Producers are recommended to remove cattle from winter wheat pastures during the first hollow-stem growth stage (Fieser et al., 2004). Fieser et al. (2004) studied grazing past this stage and observed a quadratic decrease in grain yield as cattle continued to graze past the first hollow stem stage. Lodging of the wheat is another concern, which is the crop falling over due to reaching maturity at a fast pace. Grazing wheat with cattle has been shown to decrease lodging causing an increase in yields compared to fields that are lodged (Aldrich, 1959). This wheat grazing system represents a similar system to cover crops as an integrated crop and livestock operation. Benefits to both crops and livestock can be attained with increase in productivity per hectare.

Effects of Stocking Rates on Animal Performance and Forage Quality. Varying stocking rates have been shown to affect ADG as well as forage quality. Increases in stocking rate, typically reduces ADG as animals have less forage available with lower quality available. As cattle begin to graze in an area, high quality forage is consumed first. As the high quality forage becomes less available, cattle select lower quality diets. Increasing stocking rate accentuates the decrease in forage quality. Research in this area is difficult due to outside factors that also affect forage quality. Examples of outside factors may include environmental conditions such as rainfall and temperature affecting forage throughout growing seasons. Also, throughout the growing season, quality of the pasture declines as plants are reaching maturity.

McCuistion et al., (2011) observed the relationship between increasing stocking rates and animal performance using sorghum- sudangrass (*sorghum bicolor*) hybrids. Six stocking rates were used to simulate light to heavy grazing pressures and were calculated on animal unit per day (AUD) basis. In an 84 day grazing period, linear decreases in forage availability and CP were reported. A quadratic response was observed for ADG and gain/ha as stocking rate increased. Greatest ADG and gain/ha was observed at a stocking rate of 211 and 250 AUD/ ha respectively and declined with greater stocking rates. In a similar experiment, Ackerman et al. (2001) found linear decreases in ADG and increases in gain/ ha as stocking rates increased. This contrasts the results reported by McCuistion et al. (2011) in which the increase in gain/ ha could be attributed to no decline in forage intake or quality as stocking rate increased. An explanation for the decreased ADG is difficult to extract from the data in this trial. Year to year variations in forage quantity and quality may also help explain the observed relationship in the pooled data.

The same trend exists for diet quality and stocking rates when grazing lower quality forage like cornstalks (Fernandez- Rivera and Klopfenstein, 1989). Cornstalks offer a good scenario to evaluate stocking rate effects because none of the forage is actively growing. Fernandez- Rivera (1989) reported that dietary CP and starch of extrusa samples decreased over time and with increased stocking rates. This suggests that the corn grain available in the cornstalks was consumed early in the grazing period and more rapidly as stocking rate increased. The dietary content of NDF increased over time, which would be attributed to the increased consumption of plant parts rather than grain. The digestibility of the roughage decreased more with the higher stocking rates.

The data suggests that over time, the higher quality parts were consumed first. With increased stocking rates, less of the high quality parts were available towards the end of the period compared to lower stocking rates. This cornstalk situation illustrates diet selectivity and how increasing the stocking rate increases the rate at which the higher quality forage is consumed over time.

Stocking rates effects on Forage Utilization. Utilization is defined as the forage production that is consumed or destroyed by grazing animals. In a typical grazing situation, 50% of the biomass is left after grazing. Of the other 50% that is considered utilized, 25% is the amount that typically is consumed by cattle and 25% is lost due to environment. The environmental losses are attributed to trampling by the cattle, wildlife, insects, and other similar losses. The difference in forage biomass before and after grazing determines utilization.

Utilization is commonly measured in grazing trials and can be related to intake as well as harvest efficiency, which is the quantity of forage consumed by cattle divided by the peak yield of the forage crop (Smart et al., 2010). Harvest efficiency can be improved by greater intakes or lower yields. The data of Smart et al. (2010) were combined from several locations evaluating increasing stocking rates and its effect on utilization and harvest efficiency. Utilization and harvest efficiency increased with increasing stocking rates. They also reported decreases in ADG as the stocking rates increased. However, from the data, gain/ ha increased linearly. From this it is apparent that a balance is needed between cattle performance as well as productivity per ha. Optimum stocking rates need to be calculated to meet this balance between cattle performance and productivity per hectare.

Conclusion. As cover crops are integrated into the no-till wheat farming system they may minimize the challenges associated with fallow. The biomass from cover crops could potentially be used as a source of forage for cattle producers in these no-till wheat farming regions. Cover crops may also offer a better source of nutrients compared to native pastures when grazed as well as decreasing pressure on other grazed acres. Therefore, the objective of the following experiment was to determine the differences in quality, forage production, and utilization of cover crops in a no-till farming system compared to crested wheatgrass pastures grazed by yearling cattle.

REVIEW OF THE LITERATURE II

Condensed Distillers Solubles in Feedlot Diets.

Introduction. Ethanol production in the United States has seen recent expansion due to government policies aimed at reducing air pollution. Much of this expansion occurred with dry milling ethanol plants. Dry milling ethanol plants produce two main by-products, distillers grains with solubles (DGS) and condensed distillers solubles (CDS). Feedlot studies have observed that DGS has more energy than the dry rolled corn (DRC) it replaces in the diet. There appears to be an interaction when comparing performance between DRC and steam-flaked corn (SFC) when feeding with higher concentrations of DGS. Performance increases for cattle fed DRC with high concentrations of DGS, however there is no response or decrease in performance with SFC diets. Similarly, CDS has also been shown to contain more energy than the DRC: HMC combination it replaces and possibly more energy than WDGS. Research is needed to compare CDS fed with different corn processing methods.

Corn Processing Method in Feedlot Diets. Corn is processed to increase starch utilization. The increase in starch digestibility increases animal performance (Huntington, 1997). Common methods utilized throughout feedlots in the U.S. are dry rolled (DRC), high moisture corn (HMC), and steam- flaked corn (SFC). For this review, DRC and SFC will be the two discussed. Site and extent of starch digestion is important when comparing corn processing methods and Cooper et al., (2002) reported ruminal starch digestibilities of 76.2 and 89.6% for DRC and SFC, respectively. In the same study total tract digestibilities were 96.1 and 99.8%. This is an agreement with the

review by Huntington (1997) where ruminal digestibilities were 76.2 and 84.8% and total tract digestibilities were 92.2 and 98.9% for DRC and SFC, respectively. Postruminal digestion of SFC was greater than DRC with values of 98.3 and 84.4% (entering the small intestine), respectively. It has been shown that steam-flaking corn typically increases feed efficiency 12% compared to DRC (Barajas and Zinn, 1998; Cooper et al., 2002; Corona et al., 2005). This improvement in feed efficiency is usually the result of decreased dry matter intakes and similar or increased ADG. When comparing DRC to whole corn (WC), Scott et al., (2003) observed a 7.1% improvement in feed efficiency with DRC in diets fed with wet corn gluten feed. Vander Pol et al. (2008) fed diets with WDGS comparing DRC to WC and observed a 7.8% improvement with DRC. These values illustrate the need for whole corn to be processed for feedlot diets to improve animal performance.

Dry Rolled Corn. Since whole corn grain is largely resistant to starch digestion, it can be passed between two grooved rolls to break the pericarp and decrease the particle size. When the pericarp is broke, the starch in corn is exposed allowing increased microbial degradation of the starch in the rumen. Decreased particle size results in increased surface area which allows for increased microbial attachment and degradation of starch in corn. This processing method is normally the basis of comparison and common in the feedlot industry.

Steam-Flaked Corn. Steam flaking corn is a more intensive grain processing method where corn is initially steamed in a chest and then sent through a set of corrugated rollers which results in a flake. This process is done to increase surface area like DRC, but the

steam gelatinizes the starch and ruptures starch granules when rolled (Zinn et al., 2002). A measure of flake quality control is bulk density. Corn flaked to 0.36 kg/ L (28 lbs/ bushel) was numerically greatest for efficiency and tended to have greater efficiencies than corn processed to lower flake densities (Zinn et al., 1990).

Zinn et al., (2002) suggested another method of quality control through measuring fecal starch from live cattle on a SFC based diet. A linear relationship was found where increases in fecal starch resulted in decreases in total tract digestibility. This concept of fecal starch has also been correlated to efficiency. Macken et al., (2006) found a linear relationship with fecal starch percentage and feed efficiency. As the percent fecal starch increased, feed efficiency decreased in diets with 5 different corn processing methods fed with wet corn gluten feed. This was tested with WDGS as well, (Vander Pol et al., 2008) but a quadratic relationship was observed, where an increase in fecal starch showed decreases in efficiency. In both studies, fecal starch related to efficiency helped explain the differences between corn processing methods. Conceptually, as starch utilization increases, the % fecal starch decreases, and this is observed with improved feed efficiency.

Ethanol Process. Ethanol derived from corn has become important in the last 20 years due to government efforts to reduce air pollution by using oxygenated fuels and incentives provided through blenders credits (Rausch and Belyea, 2005). The conversion of starch from corn to ethanol occurs primarily through two different processes, wet milling and dry milling. Recently, the capacity for dry milling has expanded. Stock et al. (2000) described the by- products from dry milling process. Whole stillage which is leftover from the distillation step is centrifuged to either produce wet grains or thin

stillage. The thin stillage can be further processed by means of an evaporator to produce condensed distillers solubles (CDS). The wet grains can have CDS added to be marketed as wet distillers grains with solubles (WDGS) and then can be dried to produce dried distillers grains with solubles (DDGS). In some instances CDS can be marketed as a separate commodity if a local market exists.

Wet Distillers Grains with Solubles in Feedlot Diets. Wet distillers grains with solubles (WDGS) a by-product from the dry milling ethanol process is an excellent source of protein and fat. Initially, distillers grains were fed as a protein source but as ethanol production increased more distillers grains became available. With more availability, distillers grains started to be fed as an energy source. Buckner et al., (2011) evaluated DGS samples taken from several ethanol plants in the mid-west. They reported an overall average of 31% CP and 11.9% fat. Klopfenstein et al., (2007) conducted a meta-analysis with WDGS fed at different concentrations up to 50% (DM) with DRC, HMC, or a ratio of the two corn processing methods. A quadratic decrease in DMI was noted as inclusion increased. For ADG there was a quadratic increase with the greatest ADG observed at approximately 30% (DM). There was a linear increase and tendency for a quadratic increase for feed efficiency with increased inclusion concentration of WDGS. Greatest feed efficiency was observed between 30 and 50% of diets (DM).

A large portion of CP in WDGS is UIP (Cao et al., 2009). With low amounts of DIP, the NRC (1996) may predict a DIP deficiency with cattle fed WDGS. Vander Pol (2006) observed that supplemental urea in diets containing 10 or 20% dried distillers grains (DDG) did not improve DMI, final BW, ADG, or feed efficiency. Results suggest

that feeding DDG at 10 or 20% of diet was sufficient to meet DIP requirements through recycling excess MP to urea for the rumen.

Due to the ethanol process, fat is concentrated in WDGS and may be partially responsible for increased performance relative to corn. Fat has an energy density 2.25 times that of protein or carbohydrates. This number is likely higher in ruminants, as fat has no energetic losses from fermentation compared to protein and. Type of fat is important as the rumen bacteria biohydrogenates fat before entering the intestine. Zinn et al., (2000) concluded that decreasing the amount of biohydrogenation with feeding rumen protected fat resulted in greater digestibility of unsaturated fats in the intestines.

Vander Pol et al., (2009) conducted a feeding and metabolism trial to elucidate the difference in fat sources with WDGS and corn oil. Diets were formulated to provide equal amounts of fat between WDGS and corn oil. As concentration of corn oil increased, ADG and efficiency decreased linearly. However with WDGS, there were no effects on ADG and efficiency as inclusion concentration increased. This suggests that there are inherit differences between WDGS and corn oil when compared at equal amounts of fat. In metabolism work from the same publication, cattle fed supplemental fat from WDGS had higher amounts of unsaturated fatty acids reaching the intestine compared to cattle supplemented with corn oil. The authors concluded that the data suggests less biohydrogenation with WDGS fed in finishing diets.

Fats in Finishing Diets. In feedlot diets, fat has typically been included to condition the ration as well as providing an excellent source of energy. Fat typically was not included at more than 5% (DM), but this threshold has increased since the inclusion of dry milling

byproducts at high inclusion levels such as WDGS. Pesta et al., (2012c) demonstrated that 9% dietary fat is acceptable when feeding CDS as a byproduct. One source of dietary fat is from the oil in seeds which is in a triglyceride form. Glycerol and 3 attached fatty acids make up a triglyceride. Other sources of fat in finishing diets include tallow or yellow grease. Fat supplied to the rumen in this form will be acted upon by the rumen microbes by cleaving off the glycerol which then becomes a substrate for fermentation into acetate and propionate. The remaining fatty acids are not degraded in the rumen, however they are altered in the reducing environment of the rumen through the addition of H to the fatty acids (Church et al., 1988). This mechanism, known as biohydrogenation, increases the amount of saturated fat that is leaving the rumen for intestinal digestion. Zinn et al. (2000) concluded that decreasing biohydrogenation resulted in more unsaturated fatty acids leaving the rumen and increased intestinal digestibility of fat. Research from Vander Pol (2009) confirms this and also showed less biohydrogenation with WDGS.

Corn Processing Method and Wet Distillers Grains with Solubles Interaction. There is an apparent interaction between corn processing method and WDGS. Vander Pol et al. (2008) found that feed efficiency was greatest for high moisture corn (HMC) when comparing different corn processing methods (SFC, HMC, DRC, DRC:HMC 1:1 ratio, and finely ground corn) all fed with 30% (DM) WDGS. Also in this trial, DRC had similar feed efficiency as HMC and SFC, but SFC was significantly less than HMC. This is contradictory to work with no by-products as HMC and SFC are approximately 102 and 112% the energy of DRC (Huck et al., 1998, Cooper et al., 2002). May et al., (2008) reported no interaction with 0 or 20% DDGS and steam-flaked or dry rolled corn. In

their study the authors observed a 14% response to SFC. When comparing 0 or 20% DDGS in the diet there was no significant improvement in DRC and SFC diets when DDGS was included. These data do not support the interaction between corn processing method and distillers grains inclusion concentration. One possible explanation for not seeing improvement with DRC is the inclusion of fat in the control diet. This would increase efficiency for DRC without DDGS resulting in less improvement when 20% DDGS was added. In contrast to May et al., (2008), Buckner et al., (2007) observed a 9% improvement in feed efficiency with 20% DDGS compared to the control with no DDGS or added fat.

Corrigan et al., (2009) further investigated this interaction with three different corn processing methods and increasing concentration of WDGS. Corn processing methods included DRC, HMC, and SFC. Concentrations of WDGS were 0, 15, 27.5, and 40%. Interactions were observed for final BW, ADG, and efficiency. Within DRC, final BW, ADG, and efficiency increased linearly with increasing concentration of WDGS. For HMC, final BW and ADG increased quadratically. Efficiency increased linearly within HMC. Quadratic increases in final BW and ADG were seen for SFC, but the optimum concentration was observed at the 15% inclusion which was lower than DRC and HMC. For feed efficiency with SFC, there was no difference across all concentrations of WDGS suggesting that WDGS has similar energy content as SFC.

Luebbe et al., (2011) observed a decrease in feed efficiency with increasing inclusion concentration of WDGS in SFC based diets with added yellow grease. The data would suggest that WDGS decreased the energy density of SFC and yellow grease in the diet. These differences in feed efficiency across the different corn processing

methods depict the interaction with WDGS. Collectively, WDGS improves feedlot performance in DRC based diets and maintains or decreases performance in SFC based diets.

Effect of Condensed Distillers Solubles on Performance. Lardy (2007) reported values for CDS of 20-30% CP and 9-15% fat. Sharp and Birkelo (1996) conducted a finishing study with CDS fed at 0, 5, 10, and 20% (DM) of the diet with a combination of DRC and HMC. At all concentrations of CDS, ADG was similar, but greater than the control with no CDS. Feed efficiency did not increase as concentration of CDS increased. Similarly, a finishing trial was done by Trenkle and Pingel (2004) with levels of 0, 4, 8, and 12% (DM) of CDS. No differences in performance were observed for all treatment diets. The authors suggested that CDS could replace corn without affecting performance.

Pesta et al., (2012 b,c) conducted two finishing trials with CDS replacing a 1:1 ratio of DRC to HMC with higher concentrations than in studies discussed earlier. The first study evaluated increasing concentration of CDS as the only by-product in the diet. Condensed distillers solubles were included at 0, 9, 18, 27, and 36% (DM) of the diet. As inclusion concentration of CDS increased, DMI decreased linearly, while ADG and efficiency increased quadratically. Greatest ADG was observed at 20% (DM) and greatest efficiency was observed at 32.5% (DM). In the second trial (Pesta et al., 2012b) CDS replaced a 1:1 ratio of DRC and HMC, but was fed with modified distillers grains with solubles (MDGS) or Synergy (a combination of modified distillers grains and wet corn gluten feed). Four concentrations of CDS were fed in this trial at 0, 7, 14, and 21% (DM). When CDS was fed with either MDGS or Synergy, efficiency increased linearly as inclusion concentration increased. The authors concluded that CDS can be fed in

combination with other by products as a replacement for corn. These results suggest that CDS can be fed at high concentrations similar to WDGS, but dietary sulfur or fat may be limiting factors. Nichols et al., (2012) concluded that dietary amounts of sulfur with WDGS should not exceed 0.46%.

Metabolism work with CDS has shown little effect on digestibility of diets. Pesta et al., (2012a) investigated CDS fed at 27%, 20% WDGS and 8.5% CDS, or 20% WDGS and 17% CDS on a dry matter basis. These three diets were compared to a corn control and a diet with no CDS and 20% (DM) WDGS. No differences in digestibility of DM, OM, NDF, or fat were reported. Acetate concentration was lower and acetate: propionate ratio was numerically lower for steers fed higher cooncentration of CDS.

Conclusion. Condensed distiller solubles (CDS) from the dry milling process has been shown to be an energy dense feedstuff in finishing rations by improving performance when replacing corn. An interaction has been observed with WDGS fed with different corn processing method. Limited research is available feeding CDS using different corn processing methods, thus the objective of the following experiment was to determine if a similar interaction exists with DRC or SFC fed with increasing concentration of CDS.

LITERATURE CITED

Ackerman, C. J., H. T. Purvis, G. W. Horn, S. I. Paisley, R. R. Reuter, and T. N. Bodine. 2001. Performance of light vs heavy steers grazing Plains Old World bluestem at three stocking rates. J. Anim. Sci. 79:493-499.

Aldrich, D. T. A. 1959. The effect of grazing management on the response of winter wheat to spring defoliation. Emp. J. Exp. Agric. 27: 10-16.

Allden, W. G. and P. E. Geytenbeek. 1977. Evaluation of nine species of grain legumes for grazing sheep. Proc. Aust. Soc. Anim. Prod. 13:249-252.

Barajas, R. and R. A. Zinn. 1998. The feeding value of dry-rolled corn and steam-flaked corn in finishing diets for feedlot cattle: influence of protein supplementation. J. Anim. Sci. 76: 1744-1752.

Bartholomew, H. M., and J. F. Underwood. 2002. Brassicas for forage. AGF-020-92. Dept. of Agronomy, Ohio State University, Columbus, OH.

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

Beck, P. A., C. B. Stewart, J. M. Phillips, K. B. Watkins, and S. A. Gunter. 2006. Effect of species of cool-season annual grass interseeded into Bermudagrass sod on the performance of growing calves. J. Anim. Sci. 85: 536-544.

Black, A. L., P. L. Brown, A. D. Halvorson, F. H. Siddoway. 1981. Dryland cropping strategies for efficient water-use to control saline seeps in the northern Great Plains, U.S.A. Agric. Water Manage. 4: 295-311.

Buckner, C. D., T. L. Mader, G. E. Erickson, S. L. Colgan, K. K. Karges, and M. L. Gibson. 2007. Optimum levels of dry distillers grains with solubles for finishing beef steers. Nebraska Beef Rep. MP 90: 36-38.

Buckner, C. D., M. F. Wilken, J. R. Benton, S. J. Vanness, V. R. Bremer, T. J. Klopfenstein, P. J. Kononoff, and G. E. Erickson. 2011. Nutrient variability for distillers grains plus solubles and dry matter determination of ethanol by-products. Prof. Anim. Sci. 27: 57-64.

Buttrey, E. K., F. T. McCollum III, K. H. Jenkins, J. M. Patterson, B. E. Clark, M. K. Luebbe, T. E. Lawrence, and J. C. MacDonald. 2012. Use of dried distillers grains

throughout a beef production system: Effects on stocker and finishing performance, carcass characteristics, and fatty acid composition of beef. J. Anim. Sci. 90: 2381-2393.

Campbell, C. A., R. P. Zentner, H. H. Janzen, K. E. Bowren. 1990. Crop rotation studies on the Canadian prairies. Research Branch, Agriculture Canada, Ottawa, ON. 1841/E, Canada.

Cao, Z. J., J. L. Anderson, and K. F. Kalscheur. 2009. Ruminal degradation and intestinal digestibility of dried or wet distillers grains with increasing concentrations of condensed distillers solubles. J. Anim. Sci. 87: 3013-3019.

Chen, G. and R. R. Weil. 2010. Penetration of cover crop roots through compacted soils. Plant Soil 331:31-43.

Choat, W. T., C. R. Krehbiel, G. C. Duff, R. E. Kirksey, L. M. Lauriault, J. D. Rivera, B. M. Capitan, D. A. Walker, G. B. Donart, and C. L. Goad. 2003. Influence of grazing dormant native range or winter wheat pasture on subsequent finishing cattle performance, carcass characteristics, and rumen metabolism. J. Anim. Sci. 81: 3191-3201.

Church, D. C. 1988. The ruminant animal: digestive physiology and nutrition. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Cooper, R. J., C. T. Milton, T. J. Klopfenstein, and D. J. Jordan. 2002. Effect of corn processing on degradable intake protein requirement of finishing cattle. J. Anim. Sci. 80: 242-247.

Corona, L., S. Rodriguez, R. A. Ware, and R. A. Zinn. 2005. Comparative effects of whole, ground, dry-rolled, and steam-flaked corn on digestion and growth performance in feedlot cattle. Prof. Anim. Sci. 21: 200-206.

Corrigan, M. E., G. E. Erickson, T. J. Klopfenstein, M. K. Luebbe, K. J. Vander Pol, N. F. Meyer, C. D. Buckner, S. J. Vanness, and K. J. Hanford. 2009. Effect of corn processing method and wet distillers grains plus solubles inclusion level in finishing steers. J. Anim. Sci. 87: 3351-3362.

Erickson, D. O., N. R. Riveland, and E. W. French. 1977. The nutritional value of oat hay harvested at several stages of maturity. North Dakota State Univ. Farm Research 35:2.

Fageria, N. K., V. C. Baligar, and B. A. Bailey. 2005. Role of covers crops in improving soil and row crop productivity. Communications in Soil Science and Plant Analysis 36: 2733-2757.

Fernandez- Rivera, S. and T. J. Klopfenstein. 1989. Diet Composition and Daily Gain of Growing Cattle Grazing Dryland and Irrigated Cornstalks at Several Stocking Rates. J. Anim. Sci. 67: 590-596.

Fieser, B. G., G. W. Horn, E. G. Krenzer, and S. A. Schaefer. 2004. Effect of time of grazing termination of winter wheat pasture on cattle performance and subsequent grain yield. Oklahoma State Univ. Animal Science Research Report P-1008.

Gallaher, R. N. 1977. Soil moisture conservation and yield of crops and no-till planted in rye. Soil Science Society of America 41: 145-147.

Gardner J. C. and D. B. Faulkner. 1991. Use of cover crops with integrated crop-livestock production systems. In W. L. Hargrove, ed. Cover crops for clean water. Soil and Water Conservation Society, Ankeny, IA. 185-191.

Gardner, J. C., J. B. Schatz, D. Watt, W. Goldstein, S. Guldan, A. Schlegel, J. Havlin, and R. Klein. 1992. Substituting legumes for fallow in U.S. great plains wheat production. North Central Region Sustainable Agriculture Research and Education (SARE). Univ. of Nebraska, Lincoln.

Greenquist, M. A., A. K. Schwarz, T. J. Klopfenstein, W. H. Schacht, G. E. Erickson, K. J. Vander Pol, M. K. Luebbe, K. R. Brink, and L. B. Baleseng. 2011. Effects of nitrogen fertilization and dried distillers grains supplementation: Nitrogen use efficiency. J. Anim. Sci. 89: 1146-1152.

Griffin, W. A., V. R. Bremer, T. J. Klopfenstein, L. A. Stalker, Lyle. W. Lomas, J. L. Moyer, G. E. Erickson. 2009. Summary of grazing trials using dried distillers grains supplementation. Nebraska Beef Rep. MP 92:37-39.

Haag, A. A., L. J. Held, J. A. Krall, R. H. Delaney, S. D. Miller, and D. Claypool. 2003. Replacing summer fallow with a summer grazed legume crop in rotation with wheat or wheat-sunflower-millet. J. Am. Soc. Farm Managers Rural Appraisers 66: 26-36.

Hargrove W. L. 1986. Winter legumes as a nitrogen source for no-till grain sorghum. Agronomy Journal 78: 70-74.

Hansen, N. C., B. L. Allen, R. L. Baumhardt, and D. J. Lyon. 2012. Research achievements and adoption of no-till, dryland cropping in the semi-arid U.S. Great Plains. Field Crops Res. 132:196-203.

Haynes, R. J., R. J. Martin, and K. M. Goh. 1993a. Nitrogen Fixation, accumulation of soil nitrogen and nitrogen balance for some field-grown legume crops. Field Crops Research 35: 85-92.

Haynes, R. J. and P. H. Williams. 1993b. Nutrient cycling and soil fertility in the grazed pasture ecosystem. D. L. Sparks, ed. Advances in Agronomy Academic Press, San Diego, CA Vol. 49: 119-199.

Hersom, M. J., G. W. Horn, C. R. Krehbiel, and W. A. Phillips. 2004. Effect of live weight gain of steers during winter grazing: I. Feedlot performance, carcass characteristics, and body composition of beef steers. J. Anim. Sci. 82: 262-272.

Hollingsworth- Jenkins, K. J., T. J. Klopfenstein, D. C. Adams, and J. B. Lamb. 1996. Ruminally degradable protein requirement of gestating beef cows grazing native winter Sandhills range. J. Anim. Sci. 74: 1343-1348.

Holman T., P. E. Reece, I. G. Rush, D. Baltensperger. 2001. Strategies for range beef cattle producers in arid environments following drought. NebFact 584 Available: http://digitalcommons.unl.edu Assessed: 10/29/2012.

Huck, G. L., K. K. Kreikemeier, G. L. Kuhl, T. P. Eck, and K. K. Bolsen. 1998. Effects of feeding combinations of steam flaked grain sorghum and steam-flaked, high-moisture, or dry-rolled corn on growth performance and carcass characteristics in feedlot cattle. J. Anim. Sci. 76: 2984-2990.

Huntington, G. B. 1997. Starch utilization by ruminants: from basics to the bunk. J. Anim. Sci. 75:852-867.

Janzen, H. H. 1987. Soil organic matter changes after long-term cropping to various spring wheat rotations. Can. J. Soil Sci. 67: 845-856.

Karges, K. K. 1990. Effects of rumen degradable and escape protein on cattle response to supplemental protein on native range. Univ. Neb. MS Thesis.

Karges, K. K., T. J. Klopfenstein, V. A. Wilkerson, and D. C. Clanton. 1992. Effects of ruminally degradable and escape protein supplements on steers grazing summer native range. J. Anim. Sci. 70: 1957-1964.

Klopfenstein, T. J., G. E. Erickson, and V. R. Bremer. 2007. Board-invited review: Use of distillers by-products in the beef cattle feeding industry. J. Anim. Sci. 86: 1223-1231.

Lardy, G. P. 2007. Feeding coproducts of the ethanol industry to beef cattle. AS-1242. NDSU Extension Service. North Dakota State Univ. Fargo, ND.

Larson, K. L., and J. F. Carter. 1970. Harvesting cereals for forage… in North Dakota. North Dakota State Univ. Farm Research 27:4.

Loy, T. W., J. C. MacDonald, T. J. Klopfenstein, and G. E. Erickson. 2007. Effect of distillers grains or corn supplementation frequency on forage intake and digestibility. J. Anim. Sci. 85: 2625-2630.

Luebbe, M. K., J. M. Patterson, K. H. Jenkins, E. K. Buttrey, T. C. Davis, B. E. Clark, F. T. McCollum III, N. A. Cole, and J. C. MacDonald. 2012. Wet distillers grains plus solubles concentration in steam-flaked-corn-based diets: Effects on feedlot cattle performance, carcass characteristics, nutrient digestibility, and ruminal fermentation characteristics. J. Anim. Sci. 90:1589-1602.

MacDonald, J. C., T. J. Klopfenstein, G. E. Erickson, W. A. Griffin. 2007. Effects of dried distillers grains and equivalent undegradable intake protein or ether extract on performance and forage intake of heifers grazing smooth bromegrass pastures. J. Anim. Sci. 85: 2614-2624.

Macken, C. N., G. E. Erickson, T. J. Klopfenstein, and R. A. Stock. 2006. Effects of corn processing method and protein concentration in finishing diets containing wet corn gluten feed on cattle performance. Prof. Anim. Sci. 22: 14-22.

May, M. L., M. L. Hands, M. J. Quinn, B. E. Depenbusch, J. O. Wallace, C. D. Reinhardt, K. K. Karges, M. L. Gibson, and J. S. Drouillard. 2008. Dried distiller's grains with solubles in steam-flaked or dry-rolled corn diets with reduced roughage levels. Cattleman's Day Kansas State Univ. Available: http://krex.k-state.edu/dspace/handle/2097/2410. Accessed Sep. 15, 2012.

McCartney, D., J. Fraser, and A. Ohama. 2009. Potential of warm season annual forages and Brassica crops for grazing: A Canadian Review. Can. J. Anim. Sci. 89: 431-440.

McCuistion, K. C., F. T. McCollum, L. W. Greene, J. MacDonald, and B. Bean. 2011. Performance of stocker cattle grazing 2 sorghum-sudangrass hybrids under various stocking conditions. Prof. Anim. Sci. 27: 92-100.

Miller M., and R. P. Dick. 1995. Dynamics of soil C and microbial biomass in whole soil and aggregates in two cropping systems. Applied Soil Ecology 2: 253-261.

Nichols, C. A., V. R. Bremer, A. K. Watson, C. D. Buckner, J. L. Harding, D. R. Smith, G. E. Erickson, and T. J. Klopfenstein. Meta-Analysis of the effect of dietary sulfur on feedlot health. Nebraska Beef Cattle Rep. 2012 MP95: 82-84.

NRC. 1996. Nutrient Requirements of Beef Cattle (7th Ed.). National Academy Press, Washington, D.C.

Oltjen, J. W. and K. K. Bolsen. 1980. Wheat, barley, oat, and corn silages for growing steers. J. Anim. Sci. 51:958-965.

Pesta, A. C., A. L. Shreck, T. J. Klopfenstein, and G. E. Erickson. 2012a. Metabolism of finishing diets containing condensed distillers solubles and WDGS. Nebraska Beef Cattle Rep. 2012 MP95: 68-69.

Pesta, A. C., B. L. Nuttelman, W. A. Griffin, T. J. Klopfenstein, and G. E. Erickson. 2012b. Feeding condensed distillers solubles in finishing diets containing WDGS or Synergy. Nebraska Beef Cattle Rep. 2012 MP95: 66-67.

Pesta, A. C., B. L. Nuttelman, W. A. Griffin, T. J. Klopfenstein, and G. E. Erickson. 2012c. Increasing levels of condensed distillers solubles and finishing performance. Nebraska Beef Cattle Rep. 2012 MP95: 64-65.

Rausch, K. D., and R. L. Belyea. 2005. Coproducts from bioprocessing of corn. ASAE Annual International Mtg., Tampa, FL. Paper No. 057041.

Reid, R. L., J. R. Puoli, G. A. Jung, J. M. Cox-Ganser, and A. McCoy. 1994. Evaluation of Brassicas in grazing systems for sheep: I. Quality of forage and animal performance. J. Anim. Sci. 72: 1823-1831.

Rowland I. C., M. G. Mason, I. A. Pritchard, and R. J. French. 1994. Effect of field peas and wheat on the yield and protein content of subsequent wheat crops grown at several rates of applied nitrogen. Australian Journal of Experimental Agriculture 34: 641-646.

Scott, T. L., C. T. Milton, G. E. Erickson, T. J. Klopfenstein, and R. A. Stock. 2003. Corn processing method in finishing diets containing wet corn gluten feed. J. Anim. Sci. 81: 3182-3190.

Sharp, G. A., and C. P. Birkelo. 1996. Effect of increasing levels of condensed corn distillers solbules on performance of finishing steers. Beef Rep. South Dakota State Univ. 96- 3.

Smart, A. J., J. D. Derner, J. R. Hendrickson, R. L. Gillen, B. H. Dunn, E. M. Mousel, P. S. Johnson, R. N. Gates, K. K. Sedivec, K. R. Harmoney, J. D. Volesky, and K. C. Olson. 2010. Effects of grazing pressure on efficiency of grazing on North American great plains rangelands. Rangeland Ecology and Management. 63: 397-406.

Stock, R. A., J. M. Lewis, T. J. Klopfenstein, and C. T. Milton. 2000. Review of new information on the use of wet and dry milling feed by-products in feedlot diets. J. Anim. Sci. 77:1-12.

Teasdale, J. R., and C. L. Mohler. 1993. Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. Agron. J. 85: 673-680.

Thorlacius, S. O. and S. E. Beacom. 1981. Feeding value for lambs of fababean, field pea, corn, and oat silages. Can. J. Anim. Sci 61: 633-668.

Trenkel, A., and D. Pingel. 2004. Effects of replacing corn grain and urea with condensed corn distillers solbules on performance and carcass value of finishing steers. Anim. Indust. Rep. Iowa State Univ. A. S. Leaflet R1884.

Weichenthal, B. A., D. D. Baltensperger, K. P. Vogel, S. D. Masterson, and J. M. Krall. 2008. Case study: Nutrient values of spring and summer annual forages in a single cut harvest. Prof. Anim. Sci. 24: 668-674.

Vander Pol, K. J. 2006. Factors associated with the utilization of distillers byproducts derived from the dry-milling process in finishing diets for feedlot diets. PhD Diss. Univ. of Nebraska, Lincoln.

Vander Pol, K. J., M. A. Greenquist, G. E. Erickson, T. J. Klopfenstein, and T. Robb. 2008. Effect of corn processing in finishing diets containing wet distillers grains on feedlot performance and carcass charactersistics of finishing steers. Prof. Anim. Sci. 24: 439-444.

Vander Pol, K. J., M. K. Luebbe, G. I. Crawford, G. E. Erickson, and T. J. Klopfenstein. 2009. Performance and digestibility characteristics of finishing diets containing distillers grains, composites of corn processing coproducts, or supplemental corn oil. J. Anim. Sci. 87: 639-652.

Weichenthal, B. A., D. D. Baltensperger, K. P. Vogel, S. D. Masterson, and J. M. Krall. 2008. Case study: nutrient values of spring and summer annual forages in a single cut harvest. Prof. Anim. Sci. 24: 668-674.

Wienhold, B. J., J. L. Pikul, M. A. Liebig, M. M. Mikha, G. E. Varvel, J. W. Doran, S. S. Andrews. 2006. Cropping system effects on soil quality in the Great Plains synthesis from a regional project. Renewable Agric. Food Syst. 21: 49-59.

Winter, S. R., and E. K. Thompson. 1987. Grazing duration effects on wheat growth and grain yield. Agron. J. 79: 110-114.

Zinn, R. A. 1990. Influence of flake density on the comparative feeding value of steam-flaked corn for feedlot cattle. J. Anim. Sci. 68:767-775.

Zinn, R. A., S. K. Gulati, A. Plascencia, and J. Salinas. 2000. Influence of ruminal biohydrogenation on the feeding value of fat in finishing diets for feedlot cattle. J. Anim. Sci. 78: 1738-1746.

Zinn, R. A., F. N. Owens, and R. A. Ware. 2002. Flaking corn: processing mechanics, quality standards, and impacts on energy availability and performance of feedlot cattle. J. Anim. Sci. 80: 1145-1156.

Grazing cover crops as an alternative to fallow in no-till wheat production compared to crested wheatgrass pastures[1].

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Abstract

A 2-year grazing study was conducted to evaluate forage quality and utilization of cover crops (CC) planted to replace fallow in no-till wheat systems compared to crested wheatgrass pastures (CWP). The CC mixture consisted of oats, peas and turnips with seeding rates of 44.7, 44.7, and 2.2 kg/hectare, respectively. Planting occurred in March with a no-till drill both years for the CC and both treatments (CC and CWP) were grazed during the month of June. For both years, total tract dry matter digestibility (TTDMD) and CP were greater ($P \leq 0.05$) for CC compared to CWP in hand clipped samples. The NDF and ADF content of CC were less ($P \leq 0.08$) than CWP for both years. The TTDMD and CP of the diet samples were greater ($P \leq 0.04$) for CC compared to CWP in both years. The NDF and ADF content of the diet samples were less ($P \leq 0.02$) in CC compared to CWP. In 2012, NDF digestibility and UIP content was similar ($P \geq 0.25$) between CC and CWP. Initial and final biomass was less ($P \leq 0.04$) for CC compared to CWP in 2011. In 2011, forage utilization was similar ($P = 0.40$) between CC and CWP. In 2012, initial and final biomass were similar ($P \geq 0.50$) for CC compared to CWP. Forage utilization in 2012 was similar ($P = 0.14$) between CC and CWP. CC were observed to have greater forage quality over both years and may produce similar amounts of forage as crested wheatgrass pastures. Calculations on an animal unit month (AUM) basis suggest cover crops may provide 1.54 AUM/ha of available forage.

Key words: beef cattle, cover crops, grazing, range, wheat

Introduction

Recently, producers in dry land wheat farming regions have made a shift from the typical winter wheat fallow rotation to a no-till system paired with crop rotations (Hansen et al., 2012). Problems with fallow include poor use of precipitation, increased soil erosion, and decreases in the amount of soil carbon and nitrogen (Black et al., 1981; Janzen, 1987; 1990; Wienhold et al., 2006). The no-till system with intensive crop rotations or cover crops has been shown to mitigate these problems associated with the conventional fallow (Sainju et al., 2009).

Agronomic research has shown that the components of cover crops have characteristics beneficial to subsequent crops. Combinations of cereals and legumes provide biomass to inhibit losses of water due to evapotranspiration as well as provide organic matter for the soil from their decomposing residues (Teasdale and Mohler, 1993., Miller and Dick, 1995). The legumes also provide nitrogen through fixation which can then be available to the next crop (Rowland et al., 1994). Brassicas as another component, have the ability to loosen compacted soils with their roots reducing the requirement for tillage (R. Weil and S. Williams, 2002).

The biomass from cover crops could potentially be used as a source of forage for cattle producers and return most of the nutrients to the cropping system when grazed (Thiessen Martens and Entz, 2011). Cover crops may also offer a better source of nutrients compared to native pastures when grazed, and also may decrease pressure on other grazed acres (Garnder and Faulkner, 1991, Reid et al., 1994). The objective of this experiment was to determine the differences in quality, forage production, and utilization

of cover crops in a no-till farming system compared to crested wheatgrass pastures grazed by yearling cattle.

Materials and Methods

All animal care and management procedures were approved by the University of Nebraska-Lincoln Institutional Animal Care and Use Committee.

A 2-year study (June 2011 and June 2012) was conducted at the University of Nebraska's High Plains Agricultural Lab located near Sidney, NE. Average temperature in 2011 from March through the end of June was 15˚C with 92.2 mm of precipitation. In 2012 during the same time the average temperature was 15˚C with 23.4 mm of precipitation (Weather Warehouse, 2012).

Year 1.

Treatments included in this experiment were cover crops (CC) and crested wheatgrass pasture (CWP). Oats, peas, and turnips utilized in the CC treatment were planted with a no-till drill on March 30th, 2011 in a 7 hectare wheat stubble field. Seeding rates for CC were 44.7, 44.7, and 2.2 kg/hectare for oats, peas, and turnips, respectively. The field was replicated into three 2.33 hectare paddocks. A 12.1 hectare pasture was utilized as the CWP treatment and divided into three 4.04 hectare paddocks. The CWP treatment pasture was predominantly crested wheatgrass (Agropyron cristatum), but also included buffalo grass (Bouteloua dactyloides) and blue grama (Bouteloua gracilis). Exclusion cages (n=2 per paddock) were included at the beginning of the trial to estimate production (kg/ha) of un-grazed forage. All paddocks were

sampled for biomass on 6/6/2011, 6/21/2011, and 7/5/2011 (1st, 3rd, and 5th week, respectively), by clipping a 0.5 $meter^2$ quadrat at ground level. Samples were dried in a 60˚C forced air oven for 48 hours (AOAC, 1999; method 4.2.03). Dry sample weights from the quadrat were used to calculate biomass (kg/hectare) at the given clipping date. Samples from CC treatment were sorted by each plant species and weighed individually to determine DM yields at each sampling date. Exclusion cages were sampled for biomass on 7/5/2011 to measure forage production that represents the grazing period when producers are most likely to use a cover crop.

Cattle were allowed to graze paddocks approximately 5 weeks (6/6/2011 through 7/5/2011; n=30 d). Paddocks were divided with electric fence and cattle had access to fresh water daily. Five steers were used in each paddock which resulted in stocking densities of 2.15 steers/hectare for CC and 1.24 steers/ha for CWP treatment. Stocking density was held constant over the entire grazing period. Cattle were used to measure the amount of forage removed during the grazing season to calculate utilization. Forage utilization was calculated using the following equation:

% Utilization = 100 × (($Exclusion\ cage\ biomass - Final\ biomass$) ÷ Exclusion cage biomass).

Samples were hand clipped for IVDMD, CP, NDF, and ADF by clipping forage adjacent to the quadrat (6/6/2011, 6/21/2011, and 7/5/2011). Diet quality was estimated using masticate samples collected using previously esophageally fistulated cows maintained on adjacent crested wheatgrass pastures. Three cows were utilized in the experiment and feed was withheld 12 hours before sample was collected. Diet samples

were collected for both treatments on 6/23/2011 and 7/5/20113. Diet samples were collected from one paddock in each treatment on the sampling day. All three cows were allowed access to the same paddock during sampling day. The espophageal plug was removed and bags with a screen bottom were used to obtain the samples while grazing. Diet samples and clipped quality samples were placed on ice and transported to the lab for storage at -20˚ C.

Clipped quality samples and diet samples were lyophilized (Virtis Freezemobile 25SL, Gardner, NY) and then ground to pass through a 1-mm screen in a Wiley mill (Thomas Scientific, Swedesboro, NJ). Analysis of samples included IVDMD, CP, NDF, and ADF. A modified in vitro method (Tilley and Terry, 1963) was used for IVDMD with the inclusion of 1 g/L of urea to the McDougall's buffer (Weis, 1994). Rumen fluid was collected for the procedure using 2 ruminally fistulated steers fed a smooth bromegrass hay diet. Five feed standards were included with known in vivo DM digestibility were included to form a regression equation to calculate total tract DM digestibility (TTDMD; Geisert et al., 2006). Crude protein was measured using a combustion N analyzer (AOAC, 1996; TruSpec N Determinator, Leco Corporation, St. Joseph, MI). Fiber analysis for NDF and ADF were conducted using the procedure described by Van Soest et al. (1991) with the addition of alpha amylase and sodium sulfite.

Year 2

Treatments were the same as in year 1. Planting date for CC was March 18th, 2012. The CC treatment had 12.1 ha available in 2012 and were divided into 3 paddocks

(4.04 ha in each). Paddocks for CWP were the same as year 1. Five steers per paddock were used with stocking densities for both treatments in year 2 of 1.24 steers/hectare. Procedures for exclusion cages (n=2 per paddock) and biomass sampling were the same as in yr 1 (5/30/2012, 6/12/2012, and 6/29/2012; 1st, 3rd, and 5th week, respectively). Similarly, the CC treatment was separated by species to determine DM yields at each time point. The grazing period for the cattle was 5/30/2012 through 6/29/2012 (n=31 d).

Diet samples were collected every week (n=5) for both treatments in year 2 over the grazing period with the same procedures listed in year 1. All 3 cows were allowed access to the same paddock during sampling day. In year 2, diet samples were ground to pass through a 2-mm screen and a portion of the sample was retained for in-situ analysis. The remainder of the sample and all the clipped quality samples were ground to pass through a 1-mm screen with the same procedure in yr 1. The 1-mm diet samples and clipped samples were analyzed for IVDMD, CP, NDF, and ADF with procedures described in yr 1. Diet samples retained at 2mm for in-situ analysis were incubated in ruminally fistulated steers fed a brome hay diet (ad libitum) to determine NDF digestibility and UIP content as a percent of CP. Samples were weighed into Dacron bags (Ankom, Fairport, NY) with a pore size of 50 µm. Sealed Dacron bags containing 1.25 g were placed into mesh bags. The mesh bags were incubated in ruminally fistulated steers at 3 different time points corresponding to IVDMD values. The equation : $K_p = 0.07 \times \text{IVDMD}(\%) \square 0.20$ was to calculate the rate of passage. Total mean retention time was calculated with the equation: $((1/K_p) + 10) \times 0.75$. Time points for placement of samples with varying digestibilities were calculated from these equations and bags were placed in sequentially. Samples with lower digestibilities had longer

incubation times. All bags were removed at the same time and then machine washed with 5 rinse cycles with 2 minutes of spin and 1 min of agitation (Whittet et al., 2003). Bags were then rinsed using distilled water and NDF was measured using an Ankom Fiber Analyzer 200 (Ankom, Fairport, NY). The NDF procedure was also used to correct for protein microbial attachment to the forage (Mass et al., 1999). Following incubation in NDF solution, samples were dried overnight in a 100˚C oven and weighed to determine NDF content. Values for NDF content before incubation in steers were used to calculate NDF digestibility. Remaining dried sample was analyzed for CP content with procedures described earlier to determine UIP content as a percent of the CP.

Statistical Analysis.

Hand clipped samples analyzed for nutrient content and biomass were analyzed by year. Hand-clipped samples were analyzed as a repeated measure with the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). A compound symmetry covariance structure was used. Subject was paddock within sampling date. Additionally, linear and quadratic effects of nutrient composition over the grazing season were tested. Paddock was the experimental unit. Biomass production was separated using the pDIFF option with a protected F-test. Diet sample data were analyzed by year due to differences in sampling frequency (2 vs 5 sample over the grazing season). The MIXED procedure of SAS was utilized for 2011 diet sample data with treatment pasture as the experimental unit and cow was considered a random effect. Diet sample data in 2012 was analyzed as a repeated measure with a compound symmetry structure. Treatment pasture was the experimental unit and cow was considered a random effect. Linear and quadratic effects were tested on 2012 diet sample data to identify changes in nutrient composition over the

grazing season. A compound symmetry covariance structure was used. Subject was cow within sampling date. A $P < 0.05$ was considered significant.

Results and Discussion.

Hand-clipped Forage Samples

Hand-clipped forage samples were analyzed for TTDMD and nutrient composition (CP, NDF, and ADF) and values are presented by year (Table 1). Values for TTDMD and CP were greater ($P \leq 0.05$) for CC compared to CWP over the grazing season for both years. In 2011, NDF content of CC was lower ($P = 0.02$) than CWP. In 2011, CC tended ($P = 0.08$) in ADF content than CWP. In 2012, NDF and ADF content of CC was lower ($P \leq 0.04$) than CWP over the grazing season. Within CC during 2011, TTDMD percentages decreased linearly ($P < 0.01$) across weeks (Table 2). Greatest values for TTDMD in 2011 for CC were reported on week 1 and fell 19.6% by week 5. The CP values in 2011 for CC responded quradratically ($P < 0.01$) with weeks 1 and 5 having the greatest CP content and week 3 having the lowest. In 2011, a linear ($P \leq 0.03$) increase in NDF and ADF content was observed for CC. For CC in 2011, NDF content increased 17.8% and ADF content increased 8.6% across weeks. For the CWP treatment in 2011, a linear ($P < 0.01$) decrease in TTDMD was observed. The decrease in TTDMD between week 1 and week 5 was only 10.7% for the CWP treatment compared to 19.6% in the CC treatment. In 2011, the CP content of CWP observed a tendency ($P = 0.06$) to decline linearly across weeks. The CP content declined 1.8% over the grazing period in 2011 for the CWP treatment. A linear ($P \leq 0.01$) increase in NDF content of the CWP was observed across

weeks in 2011. For the CWP, NDF content increased 8.7% from week 1 to week 5. No difference ($P \geq 0.17$) was observed for ADF content of the CWP in 2011 across weeks.

In 2012, TTDMD and CP content decreased linearly ($P \leq 0.01$) for the CC treatment. A 16.8 and 3.0% decline was observed for TTDMD and CP content, respectively. Both NDF and ADF content of the CC in 2012 increased quadratically ($P \leq 0.04$). For NDF content, an increase of 12.9% was observed from week 1 to week 3. However, from week 3 to week 5 in 2012, NDF content of the CC only increased 7.4%. Similarly, for ADF content, a large increase (8.2%) was observed from week 1 to week 3, and a small increase (1.7%) was observed from week 3 to week 5. For the CWP treatment in 2012, the only change in quality over the grazing period was TTDMD as it decreased linearly ($P < 0.01$). Over the grazing period for CWP, the TTDMD decreased 3.2%. In 2012, CP, NDF, and ADF content of the CWP were not different ($P \geq 0.47$) across the grazing period. The relatively small decrease in TTDMD and no differences in CP, NDF, and ADF content during the grazing period suggests that the CWP may have been dormant during the grazing period due to a combination of reduced precipitation and warm temperatures.

Many factors affect the nutrient composition of forages throughout a grazing period. Grazing has been shown to decrease forage quality over a grazing period (Fernandez- Rivera and Klopfenstein, 1989, McCuistion et al., 2011). Plant maturity is another factor that decreases forage quality over time (Blaser, 1965). Digestibility of plant material generally declines as it grows from a leafy vegetative state to a mature plant with increased structural carbohydrates in the forage. The data in this experiment follow this trend with decreases in TTDMD and increases in NDF and ADF content

during the grazing period. The magnitude of decrease in TTDMD and increase in NDF content was less for the CWP compared to the CC. This difference would suggest that the CWP was closer to maturity than that of the spring planted CC.

Diet Samples

The overall diet sample quality for 2011 and 2012 is shown in Table 3. Over the grazing season for both years, CC was greater ($P \leq 0.04$) in TTDMD and CP content. The observed NDF and ADF content was less ($P \leq 0.02$) for CC compared to CWP. In 2012, there was a tendency ($P = 0.10$) for a quadratic relationship for TTDMD over time for CC (Table 4.). The greatest TTDMD value was observed at week 1 and declined at week 3. However, from week 3 through the end of the grazing period (week 5) TTDMD increased. A similar tendency ($P = 0.07$) was observed for CP content of the CC which declined from week 1 to 3 and increased on weeks 4 and 5. A quadratic ($P = 0.04$) response was observed for NDF content of CC as it increased from week1 to 3 and decreased towards the end of the grazing period. There was no difference ($P \geq 0.32$) in ADF content of the CC across dates. A linear ($P = 0.05$) decrease in NDF digestibility was observed across weeks. At week 5, NDF digestibility decreased ($P = 0.02$) 32.7% from week 1. The UIP content of the CC was similar ($P \geq 0.46$) across weeks. Within the CWP treatment, linear ($P < 0.01$) decreases in TTDMD and CP content were observed across weeks. At week 5, TTDMD was 21.3% lower than week 1 for CWP. The CP content of the CWP decreased 3.1% over the grazing period. Linear ($P < 0.02$) increases in NDF and ADF content of the CWP were observed across weeks. For CWP, an increase of 13.4% was observed for NDF and 2.4% increase for ADF over the grazing season. There was a tendency ($P = 0.06$) for NDF digestibility of the CWP to decrease

quadratically. The greatest NDF digestibility was observed at week 1 and decreased 12.2% at week 2. From week 2 through the rest of the grazing season, NDF digestibility dropped only 9%, numerically ($P = 0.58$). The UIP content of the CWP was not different ($P \geq 0.13$) across sampling weeks.

The CWP treatment did follow a similar trend as the clip samples with declining forage quality over the grazing period. This linear decrease could be due little contribution from warm season grasses during the grazing season in the CWP treatment which was predominantly cool season crested wheatgrass. However, within the CC treatment the trend of declining forage quality was observed from week 1 to week 3, but an increase was observed in forage quality from week 3 through week 5. The increased IVDMD and CP values coupled with decreased NDF content in the diet samples suggest that cattle may have been consuming more grain from the oats and peas as they reached maturity. The oats and peas were producing grain in the last two weeks of the grazing period as noted with visual observations. The diet samples depict this as the NDF content would be lower and CP content would be greater in the grain with greater digestibility.

Yields of Cover Crop Species

The yields of the oats, peas and turnips within the CC were analyzed to elucidate selectivity preference of the three species when grazed (Table 5). No differences ($P \geq 0.73$) were observed for the yield (% of the total) of oats or peas across the grazing season in 2011. In 2011, turnips had a lower ($P = 0.02$) yield week 3 compared to date 1. The turnips yield at week 3 was similar ($P \geq 0.06$) to week 1 and week 5. However the small amount of turnips available (approximately 2.5% of total yield) would likely have

little effect on the selectivity of the cattle. In 2012, on week 5, the yield of oats increased ($P = 0.03$) and the yield of peas decreased ($P = 0.03$). For oats in 2012, the yields were not different ($P = 0.99$) between week 1 and week 3. Similarly, the yield of peas was also not different ($P = 0.99$) at week 1 and week 3. In 2012, turnips did not establish and grow in the CC treatment. Oats dominated the available forage in both years at 85% of the total yield with peas mainly contributing to the rest of the yield. There was a trend for oats to increase in yield and peas to decrease over the grazing period in 2012. A possible explanation of this could be a greater selection preference for peas compared to oats. Peas generally have a greater nutritive value compared to oats (Thorlacius and Beacom, 1981). However a more likely explanation is the greater accumulation of forage with oats from the yield data which may be due to oats resulting in greater forage yields (Weichenthal et al., 2001).

Forage Utilization

The total DM yields of the CC and CWP treatments were used to determine forage utilization (Table 6). In 2011, the initial biomass was greater ($P < 0.01$) for CWP compared to CC. The CWP treatment in 2011, had 648.8 kg/ha more forage available at the beginning of the grazing period. Interim, final, and exclusion cage biomass was again greater ($P \leq 0.05$) for the CWP treatment compared to CC. In 2012, there were no differences ($P \geq 0.18$) observed for initial, interim, final, and exclusion cage biomass. This would suggest that CC in 2012, produced an equivalent amount of forage compared to CWP different the observed forage production in 2011 where CC was lower than CWP.

Typically, the target utilization is 50% in perennial pasture situations in order to leave enough material for regrowth after the grazing season (Schacht et al., 2011). In the case of the CC there is a need to leave biomass after grazing for reduction in erosion, evaporation of water from soil, and added organic matter (Gallaher, 1997; Hargrove, 1986; Fageria et al., 2005). Leaving 50% of the total biomass with CC allowed for 1 month of grazing for cattle and visually left enough residue for agronomic purposes. In the current experiment, greater than 50% utilization was achieved with both treatments in 2011. There was no difference ($P = 0.40$) observed in utilization in 2011 between CC and CWP and averaged 63%. In 2012, both treatments were less than 50% utilized. Again, in 2012, there was no difference ($P = 0.14$) between CC and CWP for utilization. However, in both years, numerically CC had greater utilization percentages than CWP. The greater numeric utilization with CC in 2011 could be partially due to the increased stocking density. Utilization can be translated to forage biomass to estimate forage consumed on an animal unit month (AUM) basis. One AUM is defined as the amount of forage needed to maintain a 454 kg cow for 30 days (Waller et al., 1986; Ohlenbusch and Watson, 1994). The amount of forage that can be used for AUM calculations is 308 kg (DM) of forage. In 2011, CWP utilized more ($P < 0.01$) AUM compared to CC. No difference ($P = 0.18$) was observed for AUM's used between CC and CWP in 2012, however CC was numerically greater (Table 6). Even though grazing CC had numerically lower AUM utilized, there was numerically greater forage utilization within that treatment. The data in this experiment suggest that planted CC provide 1.54 AUM/ha of available forage biomass for grazing when averaged across both years.

Performance was calculated using the NRC (1996) equations and the observed diet quality data. Intake was predicted using past research and NRC calculations from data reported by Hardt et al., (1991) and Myer (2010). Predicted intake from these two studies suggests that intake from CWP or CC should be approximately 2.2% of BW. The average weight of the cattle over both years was used as the BW (318 kg) in NRC calculations which resulted in forage intake of 7.0 kg for both treatments based on the suggested intake of 2.2% of BW for CWP or CC. Reported values from the analysis of the diet samples in the experiment were used in the NRC, in which IVDMD was used for TDN of CC and CWP. The measured UIP was also included. Reported ADG was numerically higher for the CC treatment at 0.71 kg and the CWP treatment was estimated at 0.19 kg. Greater cattle performance is expected when grazing CC based on these NRC model predictions from the nutrient composition. The ADG predicted with CC are less than ADG observed by Beck et al., (2005) and Mullenix et al., (2012) grazing oats and a mixture of oats and ryegrass, respectively. However, the predicted ADG is still greater than CWP and may be supportive of a yearling operation by offering a greater quality forage source for growing cattle.

Implications. Overall cover crops had greater forage quality than crested wheatgrass pastures. Greater digestibilities improved predicted performance at similar intakes compared to crested wheatgrass. Depending on the year and environmental factors, cover crops may be able to produce similar amounts of forage as native pastures. Cover crops being planted on acres used for no-till wheat production offer a source of high quality forage in addition to normal grazing and haying land. This integration of crops and livestock increased productivity per unit of land compared to fallow. This integration

may offer a more sustainable approach utilizing acres for both grain and cattle production, but effects of grazing cover crops on wheat production need to be evaluated.

LITERATURE CITED

AOAC. 1996. Official Methods of Analysis. 16th ed. Assoc. Offic. Anal. Chem., Arlington, VA.

AOAC. 1999. Official methods of analysis of AAC International. 16th ed. 5th ed. 5th rev. P. Cunniff, ed. AOAC Int., Gaithersbury, MD.

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

Black, A. L., P. L. Brown, A. D. Halvorson, F. H. Siddoway. 1981. Dryland cropping strategies for efficient water-use to control saline seeps in the northern Great Plains, U.S.A. Agric. Water Manage. 4:295-311.

Blaser, R. E. 1964. Symposium on forage utilization: Effects of fertility levels and stage of maturity on forage nutritive value. J. Anim. Sci. 23: 246-253.

Fageria, N. K., V. C. Baligar, and B. A. Bailey. 2005. Role of covers crops in improving soil and row crop productivity. Communications in Soil Science and Plant Analysis 36: 2733-2757.

Fernandez- Rivera, S. and T. J. Klopfenstein. 1989. Diet Composition and Daily Gain of Growing Cattle Grazing Dryland and Irrigated Cornstalks at Several Stocking Rates. J. Anim. Sci. 67: 590-596.

Gallaher, R. N. 1977. Soil moisture conservation and yield of crops and no-till planted in rye. Soil Science Society of America 41: 145-147.

Gardner J. C. and D. B. Faulkner. 1991. Use of cover crops with integrated crop-livestock production systems. In W. L. Hargrove, ed. Cover crops for clean water. Soil and Water Conservation Society, Ankeny, IA. 185-191.

Geisert B. G., T. J. Klopfenstein, D. C. Adams, and J. C. MacDonald. 2006. Comparison of in vivo digestibility to in vitro digestibility of five forages fed to steers. J. Anim. Sci. 84 (Suppl. 2): 104. (Abstr.)

Hansen, N. C., B. L. Allen, R. L. Baumhardt, and D. J. Lyon. 2012. Research achievements and adoption of no-till, dryland cropping in the semi-arid U.S. Great Plains. Field Crops Research J. 132:196-203.

Hardt, P. F., W. R. Ocumpaugh, and L. W. Greene. 1991. Forage mineral concentration, animal performance, and mineral status of heifers grazing cereal pastures fertilized with sulfur. J. Anim. Sci. 69: 2310-2320.

Hargrove W. L. 1986. Winter legumes as a nitrogen source for no-till grain sorghum. Agronomy Journal 78: 70-74.

Janzen, H. H. 1987. Soil organic matter changes after long-term cropping to various spring wheat rotations. Can. J. Soil Sci. 67: 845-856.

Mass, R. A., G. P. Lardy, R. J. Grant, and T. J. Klopfenstein. 1999. In situ neutral detergent insoluble nitrogen as a method for measuring forage protein degradability. J. Anim. Sci. 77:1565-1571.

McCuistion, K. C., F. T. McCollum, L. W. Greene, J. MacDonald, and B. Bean. 2011. Performance of stocker cattle grazing 2 sorghum-sudangrass hybrids under various stocking conditions. Prof. Anim. Sci. 27: 92-100.

Miller M., and R. P. Dick. 1995. Dynamics of soil C and microbial biomass in whole soil and aggregates in two cropping systems. Applied Soil Ecology 2: 253-261.

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

Myer, T. L. 2010. Estimating livestock forage demand: Defining the animal unit. M.S. Thesis Univ. of Nebraska-Lincoln.

Ohlenbusch, P. D. and S. L. Watson. 1994. Stocking rate and grazing management. Kansas St. Univ. Ag. Exp. Stat. and Coop. Ext. Serv. MF-1118.

Rowland I. C., M. G. Mason, I. A. Pritchard, and R. J. French. 1994. Effect of field peas and wheat on the yield and protein content of subsequent wheat crops grown at several rates of applied nitrogen. Australian Journal of Experimental Agriculture 34: 641-646.

Sainju, U. M., A. W. Lenssen, T. C. Caesar, and R. G. Evans. 2009. Dryland crop yields and soil organic matter as influenced by long-term tillage and cropping sequence. Agron. J. 101: 243-251.

Schacht, W. H., J. D. Volesky, D. E. Bauer, and M. B. Stephenson. 2011. Grazing systems for Nebraska sandhills rangeland. University of Nebraska-Lincoln Extension Circular EC127.

Teasdale, J. R., and C. L. Mohler. 1993. Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. Agron. J. 85: 673-680.

Thiessen Martens, J. R. and M. H. Entz. 2011. Integrating green manure and grazing systems: A review. Can. J. Plant Sci. 91:811-824.

Tilley, J. M. A. and R. A. Terry. 1963. A two stage technique for in vitro digestion of forage crops. J. Brit. Grassl. Soc. 18: 104-110.

Thorlacius, S. O. and S. E. Beacom. 1981. Feeding value for lambs of fababean, field pea, corn, and oat silages. Can. J. Anim. Sci 61: 633-668.

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3597.

Waller, S. S., L. E. Moser, and B. Anderson. 1986. A guide for planning and analyzing a year-round forage program. Lincoln, NE. Nebraska Cooperative Extension EC86-113-C. 19p.

Weather Data. Weather Warehouse. Available: http://weather-warehouse.com/. Accessed 10/17/2012.

Weichenthal, B. A., D. D. Baltensperger, and K. P. Vogel. 2001. Annual forage production and quality trial. Nebraska Beef Cattle Report. MP76:26-28.

Weil, R. and S. Williams. 2002. Brassica cover crops to alleviate soil compaction. Univ. of Maryland Reseach Rep. http://enst2.umd.edu/weilbrassicacovercrops.pdf. Accessed 10/17/2012.

Weiss, W. P. 1994. Estimation of digestibility of forages by laboratory methods. Page 644 in Forage Quality, Evaluation and Utilization. G. C. Fahey., ed. Am. Soc. Agonomy, Crop Sci. Soc. American, Soil Sci Soc American, Madison, WI.

Whittet, K., K. Creighton, K. Vander Pol, G. Erickson, T. Klopfenstein. 2003. Influence of rinsing technique and sample size on in situ protein degradation. Nebraska Beef Cattle Rep. MP 80-A: 86-88.

Wienhold, B. J., J. L. Pikul, M. A. Liebig, M. M. Mikha, G. E. Varvel, J. W. Doran, and S. S. Andrews. 2006. Cropping system effects on soil quality in the Great Plains synthesis from a regional project. Renewable Agric. Food Syst. 21: 49-59.

Tables

Table 1. Overall differences in clipped quality samples for cover crops (CC) and crested wheatgrass pasture (CWP).[1]

Item	CC	CWP	SEM	*P*-Value
2011				
TTDMD	72.1	56.9	2.2	0.05
CP	10.5	7.8	0.4	0.05
NDF	46.5	67.5	1.5	0.02
ADF	34.3	41.5	1.1	0.08
2012				
TTDMD	60.1	46.3	1.1	0.02
CP	9.4	5.9	0.2	0.01
NDF	55.2	69.7	1.5	0.04
ADF	38.9	54.5	0.8	< 0.01

[1]% DM

Table 2. Clip sample forage quality for cover crops (CC) and crested wheatgrass pasture (CWP) regressed over time[1].

Item	Week 1	Week 3	Week 5	SEM	Linear[2]	Quad[3]
2011 CC						
TTDMD	84.0	76.9	64.4	2.2	< 0.01	0.32
CP	11.3	8.7	12.5	0.6	0.19	< 0.01
NDF	34.5	44.8	52.3	1.1	< 0.01	0.31
ADF	31.0	30.2	39.6	2.6	0.03	0.13
2011 CWP						
TTDMD	65.4	59.5	54.7	2.2	< 0.01	0.85
CP	9.1	7.4	7.3	0.6	0.06	0.32
NDF	62.1	68.3	70.8	1.1	< 0.01	0.18
ADF	37.7	44.6	42.3	2.6	0.24	0.17
2012 CC						
TTDMD	70.3	60.4	53.5	0.7	< 0.01	0.11
CP	11.2	9.6	8.2	0.3	< 0.01	0.72
NDF	41.3	54.2	61.6	1.0	< 0.01	0.04
ADF	32.5	40.7	42.4	1.1	< 0.01	0.03
2012 CWP						
TTDMD	49.2	46.2	46.0	0.7	< 0.01	0.13
CP	6.0	5.8	5.8	0.3	0.50	0.77
NDF	68.4	68.9	67.8	1.0	0.70	0.53
ADF	53.8	54.7	54.9	1.1	0.47	0.77

[1]Quality data combined over two years on a DM basis.
[2]Linear effect of date.
[3]Quadratic effect of date.
[4]*P*-value for the contrast between week 5 and exclusion cage quality.

Table 3. Diet sample quality data in 2011 and 2012 for cover crops (CC) and crested wheatgrass pasture (CWP)[1].

Item	CC	CWP	SEM	*P*-Value
2011				
TTDMD[2]	72.6	60.6	1.47	< 0.01
CP	9.5	7.3	0.60	0.04
NDF	50.2	69.9	0.02	< 0.01
ADF	31.6	40.9	0.02	< 0.01
2012				
TTDMD[2]	62.7	51.4	3.9	< 0.01
CP	9.3	7.4	0.7	0.01
NDF	54.2	64.4	3.5	< 0.01
ADF	39.2	47.9	3.2	0.02
NDFdig[3]	58.3	66.3	6.7	0.25
UIP[4]	29.5	32	2.9	0.41

[1]%DM.

[2]Total tract DM digestibility.

[3]NDFDig = NDF digestibility.

[4]% of CP.

Table 4. Diet sample quality for 2012 for cover crops (CC) and crested wheatgrass pasture (CWP) regressed over time[1].

Item	Week 1	Week 2	Week 3	Week 4	Week 5	SEM	Linear[2]	Quad[3]
CC								
TTDMD	73.8	71.1	54.8	60.2	58.3	2.89	0.11	0.10
CP	9.3	8.5	7.6	9.2	11.2	0.57	0.78	0.07
NDF	44.6	54.6	63.8	57.1	52.0	3.28	0.10	0.04
ADF	36.9	37.8	47.3	36.0	36.2	4.41	0.99	0.32
NDFDig.[4]	76.8	62.2	54.2	48.9	44.1	7.40	0.05	0.73
UIP[4]	31.8	32.2	30.9	23.5	28.7	3.55	0.46	0.63
CWP								
TTDMD	66.5	54.5	48.8	46.6	45.2	2.89	< 0.01	0.34
CP	9.9	7.5	7.1	6.3	6.8	0.57	< 0.01	0.3
NDF	54.6	61.7	62.2	72.4	68.0	3.28	< 0.01	0.62
ADF	43.3	49.4	47.6	55.2	45.7	4.41	0.02	0.75
NDFDig.[4]	80.8	68.6	66.7	57.0	59.6	7.4	0.70	0.06
UIP[5]	30.4	29.3	38.5	36.2	24.0	3.55	0.13	0.91

[1]% DM.
[2]Linear effect of date.
[3]Quadratic effect of date.
[4]NDFDig = NDF digestibility.
[5]% of CP.

Table 5. Yields of each crop within cover crops (CC) treatment[1].

Item	Week 1	Week 3	Week 5	SEM	*P*-Value
2011					
Oats	80.0	84.0	80.6	3.7	0.73
Peas	16.1	13.9	17.8	3.8	0.77
Turnips	3.9[a]	2.1[ab]	1.6[b]	0.5	0.06
2012					
Oats	87.9[a]	87.9[a]	94.3[b]	1.4	0.03
Peas	12.1[a]	12.1[a]	5.7[b]	1.4	0.03
Turnips	0	0	0	-	-

[1]Values are a % of the total mass measured in each clip.

Table 6. Biomass measurements of cover crops (CC) and crested wheatgrass pasture (CWP)[1].

Item	CC	CWP	SEM	*P*-Value
2011				
Initial BM	282.2	931.0	67.3	< 0.01
Interim BM	268.5	820.2	137.7	0.05
Final BM	145.2	965.0	196.6	0.04
Cage	576.3	2173.3	174.2	< 0.01
Utilization[2]	69.2	56.8	9.3	0.40
AUM[3]	3.3	15.9	1.6	< 0.01
2012				
Initial BM	1190.3	1081.3	104.3	0.50
Interim BM	1433.8	1205.7	100.3	0.18
Final BM	1156.4	1278.1	139.9	0.57
Cage	1665.0	1488.7	163.3	0.49
Utilization[2]	31.1	12.2	7.3	0.14
AUM[3]	6.7	2.8	1.7	0.18

[1]Combined over both years on a kg/ha basis.
[2]% basis.
[3]Total AUM's utilized; AUM= animal unit month (454 kg cow consuming 308 kg of forage).

The effects of corn processing method and concentration of condensed distillers solubles in feedlot finishing diets[1].

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Abstract

An experiment was conducted to determine if an interaction exists between inclusion of condensed distillers solubles (CDS) and corn processing method feedlot finishing diets. Four hundred sixty-two crossbred steers (initial BW =394 ± 16 kg) were utilized in a randomized block design. A 2 x 3 factorial treatment structure was used with one factor being corn processing method and the other CDS concentration at 0, 15, or 30% of the diet (DM basis). Corn processing methods included steam-flaked corn (SFC) or dry rolled corn (DRC). Corn, soybean meal, and urea were replaced by CDS at 15 or 30% of the diet (DM). As CDS concentration increased in the diet, DMI decreased quadratically ($P \leq 0.04$) for both SFC and DRC. Interactions ($P \leq 0.03$) were observed between corn processing method and CDS concentration for final BW, ADG, and G:F. Within DRC based diets, final BW, ADG, and G:F increased quadratically ($P \leq 0.04$) with increasing concentration of CDS. The greatest final BW and ADG were observed at the 15% concentration of CDS. The greatest G:F was observed with the 30% concentration of CDS for DRC. For SFC based diets, there were linear ($P = 0.01$) improvements in final BW and ADG as CDS concentration increased. A quadratic ($P = 0.07$) improvement in G:F was observed, with the greatest G:F observed at the 30% CDS concentration. There was a corn processing method by CDS concentration interaction ($P = 0.07$) for fat thickness. There was no difference in far thickness for DRC ($P \geq 0.48$) and a linear ($P = 0.02$) increase for SFC as CDS concentration increased. No interactions were observed for LM area, marbling score, calculated yield grade, and liver scores ($P \geq 0.16$). No differences were observed for main effects of corn processing method or CDS conentration with LM area ($P \geq 0.34$), marbling score ($P \geq 0.65$), and liver scores ($P \geq$

0.26). A corn processing method by CDS concentration interaction was observed in the finishing experiment, but when CDS replaced SFC or DRC, feedlot performance was improved.

Key words: beef cattle, finishing, condensed distillers solubles, corn processing

Introduction

Processing whole corn is common to increase utilization of starch in finishing diets. Typically, steam-flaked corn (SFC) results in a 12% improvement in G:F compared to dry rolled corn (DRC; Barajas and Zinn, 1998; Cooper et al., 2002a; Corona et al., 2005). This improvement in G:F is usually the result of decreased DMI and similar or increased ADG. Ruminal and total tract digestibilities of starch are greater for SFC when compared to DRC, which is likely the explanation for the improvement of G:F (Cooper et al., 2002 and Huntington., 1997).

Wet distillers grains with solubles (WDGS) a by-product from the dry milling ethanol process, is an excellent source of protein and energy. Klopfenstein et al., (2008) reported in a meta-analysis that WDGS increased ADG and G:F in feedlot diets. The authors suggest that WDGS has a greater feeding value than the combination of DRC and high moisture corn (HMC) it replaces. However, Corrigan et al., (2009) observed interactions for ADG and G:F with DRC or SFC fed with increasing concentrations of WDGS. In the same experiment, within DRC, ADG and G:F increased linearly; however, ADG increased quadratically and G:F was not different across all concentrations of WDGS evaluated in SFC based diets.

Condensed distiller solubles (CDS) from the dry milling process has also been shown to be an energy dense feedstuff in finishing rations improving ADG and G:F when replacing corn (Pesta et al., 2012). An interaction has been observed with WDGS fed with different corn processing methods (Vander Pol et al., 2008; Corrigan et al., 2009). Limited research is available when feeding CDS in basal diets with different corn processing methods, therefore, the objective of this experiment was to determine if a similar interaction exists with DRC or SFC fed with increasing concentration of CDS in feedlot diets.

Materials and Methods

All animal care and management procedures were approved by the University of Nebraska-Lincoln Institutional Animal Care and Use Committee.

Four hundred sixty-two crossbred steers (initial BW= 394 ± 16 kg) were utilized in a finishing trial at the Panhandle Research Feedlot located near Scottsbluff, NE. Cattle were received 2 weeks prior to initiation of the trial and initial processing included Bovi-Shield Gold 5 (a modified live virus vaccine for protection against: IBR, BVD, PI3, and BRSV; Pfizer Animal Health, New York, NY) and Vision 7 (for the prevention of Clostridium chauvoei, C. septicum, C. novyi, C. sordelli, C perfringens types C & D and Moraxella bovis; Merck Animal Health, Summit, NJ). Ivermectin was also included as a parasiticide (Ivomec; Merial, Duluth, GA). Cattle were identified with a visual panel tag and electronic identification tag.

Two weeks before initiation of the trial, cattle were limit fed (2% of BW) a common diet consisting of 25% corn silage, 25% beet pulp, and 50% alfalfa hay (DM basis). Weights were recorded on d 0 and d 1 of the trial, and the average was used as initial BW. A randomized block design was utilized and cattle were blocked by d 0 weight (n=3 BW blocks), stratified within block and assigned to one of 42 feedlot pens (11 steers/ pen). The BW blocks consisted of 24, 12, and 6 pens in the light, medium, and heavy BW blocks, respectively. Pens were assigned randomly to treatments. On d 1, cattle in the light BW block received a Component TE-IS (Elanco Animal Health, Greenfield, IN) and the middle and heavy BW blocks received Component TE-S (Elanco Animal Health, Greenfield, IN). The light BW block was re-implanted on d 70 with Component TE-S (Elanco Animal Health, Greenfield, IN).

Dietary treatments were arranged in a 2 x 3 factorial with factors being corn processing method (DRC or SFC), and the second factor concentration of CDS (0, 15, or 30%; DM basis). Inclusion of CDS replaced a portion of corn, soybean meal, and urea (Table 1). Adaptation to the finishing diet occurred over an 18 d period where corn replaced alfalfa hay. Adaptation consisted of 4 steps and alfalfa hay was included at 39.5, 30.5, 21.5, and 12.5% (DM basis) and fed for 4, 4, 5, and 5 d, respectively. Inclusion of CDS, silage, and supplement remained the same in all steps as in the finishing diets. Soybean meal and urea were included to meet or exceed calculated MP requirements in treatment diets (NRC, 1996). All diets contained 4.0% (DM basis) of a pelleted supplement which was formulated to provide 360 mg/hd/d of monensin (Rumensin, Elanco Animal Health) and 90 mg/hd/d of tylosin (Tylan, Elanco Animal Health).

The CDS used in this trial was purchased from one source (Colorado Agri Products, Bridgeport, NE) and average nutrient composition was 24.3% DM, 16% CP, 20.3% fat, and 0.39% S. The SFC was purchased from a local commercial feedlot and delivered 3 times weekly (Panhandle Feeders, Morrill, NE). The target flake density for the commercial feedlot was 360 g/L (28 lbs/bushel). The DRC was processed on site and measured for particle size using United States Bureau of Standard Sieves #1 (9500µm), #3 (6300 µm), #4 (4760 µm), #6 (3360 µm) #12 (1680 µm), #30 (590 µm), and #70 (212 µm). Samples were wet sieved using a Fritsch Analysette particle separator (Model 8751, Germany). The geometric mean diameter was 4098 µm with a geometric standard deviation of 1.5 µm derived from calculations described by Behnke (1994).

All ingredients were sampled weekly, composited, and analyzed as one sample in a commercial laboratory for CP, NDF, fat, Ca, P, K, S, and starch (Servi-Tech Laboratories, Hastings, NE). Feed bunks were evaluated at approximately 0600 h and managed for only traces of feed remaining at feeding (0800 h). Feed refusals were removed from bunk as needed, weighed, and dried in a forced-air oven for 48 h at 60˚C for DM determination (AOAC Method 930.15).

At re-implant on d 70, fecal grab samples were obtained from all steers in the light BW block and half of the middle block (n= 5 replications per treatment). Approximately 15 g of as-is fecal material was collected from each steer and then composited by pen (approximately 165 g). Fecal composites of each pen were placed on ice and then frozen at -20˚C. Composites were thawed and then dried in a forced-air oven for 48 h at 60˚C. After drying, composites were ground to pass through a 0.5mm screen in a Cyclotec sample mill (1093 Sample Mill Foss, Hillerod, Denmark). Fecal pen

composites were analyzed for total stach content using the Megazyme procedure with amyloglucosidase enzyme hydrolysis (AOAC method 996.11, 2003; Megazyme International Ireland, Wicklow, Ireland).

The middle and heavy BW blocks were harvested on d 119 and the light block was harvested on day 132 at Cargill Meat Solutions (Ft. Morgan, CO). Carcass data were collected by Diamond T Livestock Services (Yuma, CO). Hot carcass weight (HCW) and liver scores were collected on the day of slaughter. Fat thickness, LM area, and marbling score were collected after a 48-h carcass chill. Calculated yield grade was determined using the carcass measurements and the formula determined by Boggs and Merkel (1998) using a an assumed KPH of 2.0%. Final BW, ADG, and G:F were calculated using HWC adjusted to a common 63% dressing percentage.

Values for the energy relative to the corn used in the diet were calculated with the NRC (1996) model equations. The TDN values used for this calculation were DRC: 90, SFC: 100.80, (111.2% of DRC in the current experiment), corn silage: 75, alfalfa hay: 58, soybean meal: 84, and urea: 0. Calculations were separate for each corn processing method based on the 0% inclusion level of CDS. The 0% inclusion level diets were entered into the NRC and the NEm and NEg adjusters were altered to show the actual performance in the experiment. For DRC based diets the adjusters were set at 78.2% and for SFC they were set at 74.6%. The adjusters were then held constant and diets were altered to the treatment diets. The TDN value of CDS was then adjusted to match the observed ADG for the treatment. The calculated TDN values of CDS were then divided by the TDN value of the corn to calculate the relative energy value to corn.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Corn processing method, CDS inclusion concentration, and corn processing method x CDS inclusion concentration were included in the model. Pen was the experimental unit and BW block was included as a random effect. Orthogonal contrasts were used to test linear and quadratic effects of CDS inclusion concentration across both corn processing types when no interaction was observed. When a significant ($P < 0.05$) interaction was observed, linear and quadratic effects were tested within corn processing method.

Results and Discussion

Feedlot performance data.

No interaction ($P = 0.14$) between corn processing method and CDS concentration was observed for dry matter intake (Table 2). Dry matter intake for both SFC and DRC fed cattle decreased quadratically ($P \leq 0.04$) as CDS concentration increased. Pesta et al., (2012) observed a linear decrease in DMI with increasing concentration of CDS fed with a basal diet that included a 1:1 ratio of DRC: HMC, whereas in the current trial quadratic decreases were observed. Dietary sulfur has been shown to decrease DMI (Sarturi et al., 2010), but in the current trial this is unlikely due to relatively low dietary sulfur concentrations (Table 1). The greatest dietary S value was observed with diets that consisted of 30% CDS (0.13%). Sulfur concentration in the CDS used in the current trial was 0.39% which is less than 1.1% reported by Pesta et al., (2012). The decrease in DMI is likely due to increased energy density of the diet (Zinn et al., 2008). As CDS concentration increased in the diet, dietary fat also increased (Table

1). The fat from CDS would presumably increase the energy density of the diet. Dietary fat at the 30% concentration of CDS was approximately 7.0% with both corn processing methods. Corn processing method did not have an effect on DMI ($P = 0.30$). However, numeric differences were observed as the intakes at the 15% CDS concentration were slightly less for SFC compared to DRC. Typically, DMI is less for cattle fed SFC compared to DRC (Macken et al., 2006, Vander Pol et al., 2008). At the 30% concentration of CDS, DMI was numerically greater for SFC compared to DRC.

Corn processing method by CDS concentration interactions ($P \leq 0.03$) were observed for final BW, ADG, and G:F. Within DRC based diets, final BW and ADG increased quadratically ($P < 0.01$) with increasing concentration of CDS. The greatest final BW and ADG were observed at the 15% concentration of CDS. The increase in ADG coupled with the decrease in DMI resulted in quadratic ($P = 0.04$) improvements in G:F within DRC based diets. In contrast to ADG and final BW, the greatest G:F was observed with the 30% concentration of CDS. Maximal G:F was observed at the highest concentration of CDS is in agreement with Pesta et al. (2012). An increase in G:F of 14.6% was observed when CDS increased from 0 to 15% CDS in DRC diets. An improvement of 4.3% was observed when increasing the CDS concentration from 15 to 30% in DRC diets. These results differ from Sharp and Birkelo (1996) and Trenkle and Pingel (2004) with no differences due to CDS inclusion on G:F with incremental concentrations fed up to 20% (DM), suggesting that CDS has a similar amount of energy compared to the corn it replaced. In contrast, the current trial is in agreement with Pesta et al. (2012), as CDS was observed to have a greater relative energy value compared to DRC.

Final BW and ADG increased linearly ($P = 0.01$) in SFC based diets as CDS concentration increased, whereas a different response was observed for DRC based diets. In SFC based diets, the 30% concentration of CDS, final BW was 13 kg greater than the 0% CDS concentration. An improvement of 5.9% for ADG was observed at the 30% concentration compared to the 0% concentration. Again, with the decrease in DMI and increase in ADG with increasing concentration of CDS, G:F improved with a quadratic ($P = 0.07$) response. When CDS was included at 15% of the diet an improvement of 5% was observed compared to the 0% concentration. When comparing the 15% concentration to the 30% concentration there was an additional 12% improvement in G:F. In contrast to Corrigan et al. (2009) who observed no improvement in G:F with increasing concentration of WDGS in SFC based diets, the current study showed improvements with increasing concentration of CDS. Corrigan et al. (2009) and the current study both observed 11-12% improvements in G:F when corn processing methods were compared without by-products and agrees with other research comparing corn processing methods (Barajas and Zinn, 1998; Cooper et al., 2002a; Corona et al., 2005).

Carcass Characteristics.

A corn processing method by CDS concentration interaction ($P < 0.01$) was also observed for HCW (Table 2). For DRC based diets, HCW increased quadratically ($P < 0.01$) and SFC based diets increased linearly ($P = 0.01$) with increasing concentrations of CDS. Greatest HCW was observed at the 15% concentration of CDS for DRC based diets and 30% concentration level for SFC based diets. The observed results with DRC based diets are in agreement with Pesta et al., as maximal HCW was observed at the 15-18% concentration of CDS. There tended ($P = 0.07$) to be an interaction for 12th rib fat

thickness. There was no difference ($P = 0.88$) across CDS concentration for DRC, but a linear ($P = 0.02$) increase in fat thickness observed for SFC based diets. No interactions ($P \geq 0.16$) were observed for LM area, marbling score, calculated yield grade, or incidence of liver abscesses. There was no main effect of corn processing method ($P = 0.34$) or main effect of CDS inclusion concentration ($P = 0.53$) on LM area. Marbling score was not different for the main effect of corn processing method ($P = 0.79$) or main effect of CDS inclusion concentration ($P = 0.65$). Yield grade tended ($P = 0.09$; main effect of corn processing method) to be greater for SFC cattle compared to DRC. There was a linear ($P = 0.01$) increase in yield grade for SFC fed cattle with increasing concentration of CDS. No difference ($P = 0.84$) was observed within DRC based diets as CDS concentration increased. No effects were observed for liver abscess incidence due to main effect of corn processing method ($P = 0.29$) or main effect of CDS inclusion concentration ($P = 0.26$). Pesta et al. (2012) reported no differences for LM area, 12th rib fat thickness, calculated yield grade, and marbling score with increasing concentration of CDS in DRC:HMC (1:1 ratio) based diets. Similarly, in the current study, there was no difference ($P \geq 0.12$) due to main effect of CDS concentration on LM area, marbling score, or calculated yield grade. In the current study, corn processing method had a greater influence than CDS concentration on carcass characteristics with greater fat deposition and yield grade in SFC based diets compared to DRC.

Fecal Starch.

Fecal starch percentages for each treatment are presented in Table 2. Fecal starch percentage may indicate the extent of starch utilization (Zinn et al., 2002). The authors determined that fecal starch explained 91% of the variation in total tract starch digestion.

As fecal starch decreases, total tract digestibility increases which may improve performance. Macken et al., (2006) observed an increase in G:F as the amount of fecal starch decreased when comparing corn processing methods. In the present study, no corn processing method and CDS concentration interaction was observed ($P = 0.77$) for fecal starch. Fecal starch was lower for SFC than DRC ($P < 0.01$, main effect of corn processing method). No effect ($P = 0.34$) due to CDS inclusion concentration was observed for fecal starch. Macken et al. (2006) and Vander Pol et al. (2012) reported lower fecal starch values for SFC compared to DRC fed with wet corn gluten feed or WDGS which in agreement with the present study. Macken et al. (2006) and Vander Pol et al. (2008) observed 12-20% fecal starch in DRC based diets and 4% fecal starch in SFC based diets. Absolute numbers in the current study are greater for fecal starch with SFC which were approximately 11.5% when compared to numbers above. Values in the current study for DRC (19.5% fecal starch) agree with Macken et al. (2006). The data from the current study suggest CDS concentration had little effect on fecal starch.

Energy Values.

Within DRC, CDS was 157% the energy of DRC at the 15% inclusion concentration and 144% at the 30% inclusion concentration using the NRC (1996) calculations. Within SFC, CDS was 124% the energy of SFC at the 15% inclusion concentration and 136% at the 30% concentration. The second method used was a relative feeding value based on observed G:F versus the 0% concentration G:F (Pesta et al., 2012). In the current study, within DRC, CDS was 198% at the 15% concentration and 165% at the 30% inclusion concentration. Within SFC, CDS was 134% at the 15% concentration and 159% at the 30% inclusion concentration. These energy values

suggest that CDS has greater energy than WDGS. Bremer et al., (2011) reported feeding values of 150, 143, and 136% for WDGS when replacing DRC and HMC at 10, 20, and 30% of the diet (DM). Feeding values for CDS replacing DRC at the 30% concentration was 29% greater than WDGS at the same concentration in the diet. For steam flaked corn basal diets, again the data suggest the feeding value of CDS is greater than WDGS. Corrigan's et al., (2009) data suggests that WDGS has similar energy as SFC due to no improvement in G:F with increasing concentration of WDGS. In contrast to Corrigan et al., (2009) the present study showed improvements in G:F and greater energy values at the 15 (24-34%) or 30% (36-59%) concentration depending on calculation method.

Implications.

Results from the current study suggest that corn processing method interacts with inclusion of CDS. The response, however, was different than what has been observed with WDGS as increasing concentrations of CDS improved ADG and G:F in SFC based diets. With either corn processing method, relative energy and feeding values for CDS are much greater than the corn it replaced. The response reported with SFC suggests that the optimum concentration of CDS may be more than 30% (DM) in the diet and warrants future investigation.

LITERATURE CITED

AOAC. 2003. Official Methods of Analysis. 15th ed. Assoc. Off. Anal. Chem., Arlington, VA.

Barajas, R. and R. A. Zinn. 1998. The feeding value of dry-rolled corn and steam-flaked corn in finishing diets for feedlot cattle: influence of protein supplementation. J. Anim. Sci. 76: 1744-1752.

Behnke, K. C. 1994. Determining and expressing particle size. In: R. McEllhiney (tech ed.) Feed manufacturing technology IV. P 545. American Feed Industry Assoc., Arlington, VA.

Boggs, D. L., and R. A. Merkel. 1993. Beef carcass evaluation, grading, and pricing. Kendel/ Hunt Publishing Co., Dubuque, IA.

Cooper, R. J., C. T. Milton, T. J. Klopfenstein, and D. J. Jordan. 2002. Effect of corn processing on degradable intake protein requirement of finishing cattle. J. Anim. Sci. 80: 242-247.

Corona, L., S. Rodriguez, R. A. Ware, and R. A. Zinn. 2005. Comparative effects of whole, ground, dry-rolled, and steam-flaked corn on digestion and growth performance in feedlot cattle. Prof. Anim. Sci. 21: 200-206.

Corrigan, M. E., G. E. Erickson, T. J. Klopfenstein, M. K. Luebbe, K. J. Vander Pol, N. F. Meyer, C. D. Buckner, S. J. Vanness, and K. J. Hanford. 2009. Effect of corn processing method and wet distillers grains plus solubles inclusion level in finishing steers. J. Anim. Sci. 87: 3351-3362.

Huntington, G. B. 1997. Starch utilization by ruminants: from basics to the bunk. J. Anim. Sci. 75:852-867.

Klopfenstein, T. J., G. E. Erickson, and V. R. Bremer. 2007. Board-invited review: Use of distillers by-products in the beef cattle feeding industry. J. Anim. Sci. 86: 1223-1231.

Macken, C. N., G. E. Erickson, T. J. Klopfenstein, and R. A. Stock. 2006. Effects of corn processing method and protein concentration in finishing diets containing wet corn gluten feed on cattle performance. Prof. Anim. Sci. 22: 14-22.

Pesta, A. C., B. L. Nuttelman, W. A. Griffin, T. J. Klopfenstein, and G. E. Erickson. 2012c. Increasing levels of condensed distillers solubles and finishing performance. Nebraska Beef Cattle Rep. 2012 MP95: 64-65.

Sarturi, J. O. 2012. Sulfur from wet or dry distillers in feedlot cattle diets and the ruminal available sulfur concept. PhD Dissertation Univ. of Nebraska-Lincoln.

Sharp, G. A., and C. P. Birkelo. 1996. Effect of increasing levels of condensed corn distillers solbules on performance of finishing steers. Beef Rep. South Dakota State Univ. 96- 3.

Trenkel, A., and D. Pingel. 2004. Effects of replacing corn grain and urea with condensed corn distillers solbules on performance and carcass value of finishing steers. Anim. Indust. Rep. Iowa State Univ. A. S. Leaflet R1884.

Vander Pol, K. J., M. A. Greenquist, G. E. Erickson, T. J. Klopfenstein, and T. Robb. 2008. Effect of corn processing in finishing diets containing wet distillers grains on feedlot performance and carcass charactersistics of finishing steers. Prof. Anim. Sci. 24: 439-444.

Zinn, R. A., A. Barreras, F. N. Owens, and A. Plascencia. 2008. Performance by feedlot steers and heifers: Daily gain, mature body weight, dry matter intake, and dietary energetics. J. Anim. Sci. 86:2680-2689.

Zinn, R. A., F. N. Owens, and R. A. Ware. 2002. Flaking corn: processing mechanics, quality standards, and impacts on energy availability and performance of feedlot cattle. J. Anim. Sci. 80: 1145-1156.

Tables

Table 1. Composition of diets (% of diet DM) fed to finishing steers.

	Dry-Rolled Corn[1]			Steam-Flaked Corn[2]		
CDS Level	0%	15%	30%	0%	15%	30%
Corn	83.59	69.54	55.50	82.19	68.70	55.34
CDS[3]	0.00	15.00	30.00	0.00	15.00	30.00
Corn Silage	7.00	7.00	7.00	7.00	7.00	7.00
Alfalfa Hay	3.50	3.50	3.50	3.50	3.50	3.50
Supplement[4]	4.00	4.00	4.00	4.00	4.00	4.00
Soybean Meal	1.30	0.65	0.00	2.70	1.40	0.00
Urea	0.61	0.31	0.00	0.61	0.40	0.16
Nutrient Composition %						
CP	12.22	11.86	11.50	12.50	12.13	11.72
Fat	3.28	5.27	7.25	2.68	4.77	6.86
Sulfur	0.09	0.11	0.13	0.10	0.12	0.13

[1]Geometric mean diameter = 4098.3 µm, geometric standard deviation = 1.54 µm.
[2]Target flake density was 360 g/L (28 lbs/bu).
[3]CDS= condensed distillers solubles, Colorado Agri Products, Bridgeport, NE.
[4]Formulated to provide 360 mg monensin and 90mg of Tylan® per head/daily.

Table 2. Effect of corn processing method and condensed distillers solubles (CDS) inclusion level on performance and carcass characteristics.

	Dry-Rolled Corn			Steam-Flaked Corn				*P* – value[1]		
CDS Level	0	15	30	0	15	30	SEM[2]	Corn	CDS	Inter
Performance										
Initial BW, kg	394	394	394	394	394	394	36	0.91	0.34	0.83
Final BW, kg[3,4,5]	607	630	612	625	630	638	8	< 0.01	< 0.01	< 0.01
DMI, kg/d[6]	12.1	11.8	10.5	11.8	11.6	10.7	0.7	0.30	< 0.01	0.14
ADG, kg[3,4,5]	1.74	1.93	1.79	1.88	1.93	1.99	0.10	< 0.01	< 0.01	< 0.01
G:F[3,4,5,7,8]	0.143	0.164	0.171	0.159	0.167	0.187	0.007	< 0.01	< 0.01	0.03
Fecal Starch, %	19.3	20.7	18.4	12.8	12.1	9.5	1.8	< 0.01	0.34	0.77
Carcass Characteristics										
HCW, kg[4,5]	382	397	386	393	397	402	5	< 0.01	0.01	< 0.01
12th Rib Fat Thickness, cm[4]	1.42	1.40	1.42	1.40	1.52	1.52	0.01	0.02	0.23	0.07
LM area, cm sq.	83.4	84.3	82.3	83.9	83.9	83.9	2.3	0.34	0.53	0.42
Marbling score[9]	551	558	554	553	555	559	14	0.79	0.65	0.81
Yield Grade[4,10]	3.43	3.43	3.45	3.39	3.57	3.61	0.11	0.09	0.12	0.16
Liver abscess, %	14.3	9.2	8.0	7.9	11.8	3.9	-	0.29	0.26	0.38

[1]Corn = main effect of corn processing method, CDS = main effect of condensed distillers solubles inclusion level, Inter = corn processing method and condensed distillers solubles inclusion level interaction.

[2]SEM = standard error of the mean for the interaction.

[3]Final BW calculated from hot carcass weight, adjusted to a common dressing percentage of 63.

[4]Linear effect of CDS within SFC ($P < 0.05$).

[5]Quadratic effect of CDS within DRC ($P < 0.05$).

[6]Quadratic effect of CDS across all treatments ($P < 0.05$).

[7]Linear effect of CDS within DRC ($P < 0.05$).

[8]Quadratic effect of CDS within SFC ($P = 0.07$).

[9]Marbling score: 400 = Slight 0, 500 = Small 0

[10]Yield grade = 2.5 +6.35(fat thickness, cm) – 2.06(LM area, cm^2) + 0.2(KPH fat, %) + 0.0017(hot carcass weight, kg).