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# Backgrounding Calf Management Strategies Using Corn Residue and Double Cropped Forages

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BACKGROUNDING CALF MANAGEMENT STRATEGIES USING CORN RESIDUE AND DOUBLE CROPPED FORAGES

by

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Approximately 70% of calves in the U.S. are born in the spring and weaned in the fall, this results in a large supply of calves potentially available for backgrounding over the winter. Backgrounding systems positively impact the beef industry by efficiently using forage resources available. These systems also provide production value by enhancing the calf's frame size, mature BW (increase HCW), and health prior to entering the feedlot. In Nebraska opportunities to integrate both crop and livestock production, by backgrounding calves abound. Approximately 13,100 metric tons of corn residue or 34,000 Animal Unit Months are available for grazing in Nebraska. However, 37% of crop producers surveyed in Nebraska, indicated that they do not allow grazing of their corn residue. Producers that did not graze cited concerns of soil compaction, inconveniency (watering and fencing), and lack of access to livestock as major deterrents. Planting cool-season grasses (oats) and brassicas (turnip and radish) immediately after corn silage harvest in mid-late August, can also be a potential winter forage source for grazing. The oat-brassica forage had DM yields ranging from 3,756 to 5,144 kg/ha and relatively high nutritive values, with IVDMD ranging from 83 to 89% and CP ranging from 16 to 25%. Gains of steers grazing corn residue and supplemented with distillers at 0.86% of their BW ranged from

0.24 to 0.79 kg/d and 0.47 to 0.94 kg/d for steers grazing an oat-brassica forage during the winter. All 3 treatments finished with a similar 12th rib fat and calculated YG. However, steers that previously grazed did have increased finishing DMI and decreased G:F when compared to steers solely fed a corn silage-based diet during the backgrounding phase. The grazing treatments had a greater HCW and LM area than steers fed a corn silage-based diet. However, steers grazing corn residue did have a slight reduction in marbling. Yet, the difference observed for marbling was minor and would not be great enough to merit discounts or premiums for carcasses. These backgrounding systems are a practical way to integrate crop and livestock production systems, in order to best utilize the abundant resources available in Nebraska.

Key words: backgrounding beef steers, brassicas, carcass quality, agriculture survey, grazing corn residue, annual forages

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DEDICATION

"Trust in the Lord with all your heart and lean not on your own understanding; in all your ways submit to him, and he will make your paths straight."

~ Proverbs 3: 5-6, The Holy Bible, NIV

"Consider it pure joy, my brothers and sisters, whenever you face trails of many kinds, because you know that the testing of your faith produces perseverance. Let perseverance finish its work so that you may be mature and complete, not lacking anything."

~ James 1: 2-4, The Holy Bible, NIV

"There are different kinds of gifts, but the same Spirit distributes them. There are different kinds of service, but the same Lord. There are different kinds of working, but in all of them and in everyone it is the same God at work."

~ 1 Corinthians 12: 4-6, The Holy Bible, NIV

"Jesus looked at them and said, "With man this is impossible, but with God all things are possible."

~ Matthew 19: 26, The Holy Bible, NIV

"And whatever you do, whether in word or deed, do it all in the name of the Lord Jesus, giving thanks to God the Father through him."

~ Colossians 3: 17, The Holy Bible, NIV

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## Introduction

*Overview of backgrounding systems for growing calves*

The beef industry has always been and continues to be a complex system containing many production stages such as cow-calf, growing, and finishing to reach the ultimate goal of a slaughter-ready beef animal. Stocker or backgrounding (growing) programs are the most variable of these stages (Peel, 2003). Differences in topography, feed resources (forage), cattle type, and markets play a significant role in a producer's decision on which growing system they will use. Since approximately 70% of calves in the U.S. are born in the spring and subsequently weaned in the fall, it results in a large supply of calves available to enter the feedlot all at once (Peel and Ward, 1994). At the beginning of each yr it is estimated that 78.5% of the previous year's calf crop are still available as feeder calves, to continue being backgrounded or to enter the finishing stage in a feedlot at this time. The other 21.5% of calves were placed directly into finishing feedlots, heifers and bulls held for reproduction, and calf slaughter (Peel, 2003). Overall backgrounding calf numbers may change throughout the yr, due to the varying lengths of time in different growing systems (short-yearling or long-yearling). Backgrounding systems positively impact the beef industry by making the most of forage resources available and providing an economically feasible approach to adjusting the timing and supply of beef in a complex market environment (Parsons, 1996).

*Concept and purpose of the backgrounding systems*

Due to the various types of backgrounding systems it is difficult to define exactly what backgrounding is, and what type of cattle pertain to this stage. There is no set calf weight, frame size, age, breed, geographical region, environment, or forage source that represents the majority of the backgrounding industry. However, three common characteristics of backgrounding systems were identified by Peel (2003) in a review of beef cattle growing and backgrounding programs.

First of all, calf growth is one of the main objectives of backgrounding; which refers specifically to frame and muscle growth, instead of fattening (finishing) (Peel, 2003; Perillat et al. 2003). This explains why the typical backgrounding system takes calves at weaning and adds 91 to 181 kg of weight to them over a 3 to 8 mo time span, before they are placed in the feedlot for finishing (Peel, 2003). Owens et al. (1993) indicates that backgrounding cattle, subsequently shifts their mature BW up by increasing the accretion of protein mass. Owens et al. (1993), further defines mature BW as the point of maximum protein mass, despite an increase in overall empty body weight (EBW) due to fat deposition if cattle are continued to be fed past maximum protein accretion. This goal provides production value by enhancing the calf’s frame size, mature BW (increase HCW), and health after weaning and prior to entering the feedlot.

Secondly, backgrounding systems typically depend on forage-based rations as their primary feed stuff. Generally these forages are seasonally grazed, but harvested forages are also utilized in full and semi confinement systems. It is also common for these enterprises to include smaller portions of concentrate feeds in the diets of these growing animals, either as a supplement to calves grazing or in growing rations to backgrounding calves in a feedlot.

Finally, in order for producers to receive optimum returns or at least remain financially stable, these backgrounding production systems must be a viable economic enterprise, apart from other sectors of their production system (Peel, 2003). Particularly in the Midwest, the backgrounding phase is just a portion of what the cattle producer, or in some cases throughout the Corn Belt region the crop producer is involved in. After weaning of calves, cow-calf enterprises can decide to either sell them to a feedlot or standalone stocker operation or retain them and background them on forages such as corn residue before selling to a feedlot. Feedlot enterprises, in the Midwest where cash crop byproducts are abundant, may decide to purchase calves in excess of their drylot capacity and background them. By doing this the feedlots ensure a constant supply of calves throughout the yr. However, there are many factors that affect the economic viability of differing backgrounding systems; including location, feed prices, market, and cattle weight. Thus it is important for each producer to analyze their particular situation before making backgrounding management decisions.

*Type of backgrounding systems utilized*

Backgrounding systems can typically be lumped into two categories: grazing systems or confinement backgrounding. In general both of these systems incorporate forage as the major feed source for growing calves.

One of the main ways to minimize cost and promote increased profit is to graze forages as often as possible rather than spending time and money to harvest and feed forages. However factors such as climate, soil properties, and local agriculture culture can influence the availability of forages for grazing (Brown, 1985). Some regions in the U.S. try to extend the use of high quality forages by overlapping two or more sources of forage, but for many places this goal is hard to achieve. This concept can be applied in the Midwest by grazing crop residue after grain harvest during the winter, followed by winter wheat grazing (specifically in Kansas) through the spring, and lastly native grasslands such as the Flint Hills of Kansas or the Sandhills of Nebraska over the summer. Double cropped forages could also be implemented into the system by either grazing them during the winter in the place of corn residue grazing or through the spring following corn residue grazing. Any or all of these forages can be utilized by the producer backgrounding calves, depending on the availability of these forages or their resources to produce these types of forages. If producers just graze calves over the winter before selling them to the feedlot, they are considered short-yearlings. Calves that are grazed over the winter and additionally backgrounded through the spring and/or during the summer before going to the feedlot would be considered long-yearlings. Each region and forage system creates unique opportunities and challenges.

Confined or semi-confined backgrounding systems also contribute to the calf growing sector of beef production. These systems are most commonly found in the Corn Belt states (specifically Nebraska and Iowa) and typically use a forage-based ration or limit-feeding diet to elicit growth rather than fattening them, which is typically done in a finishing yard. At first glance the overall appearance of these types of backgrounding systems are very similar to a finishing feedlot, however nutritional and health management of the cattle are often different (Peel, 2003).

Some of the most common forages used in these growing diets include: corn silage, alfalfa hay, green chop, or grain residues (corn/sorghum residue or wheat stubble). It is generally cheaper to graze these forages rather than mechanically harvest them, but having control of what the cattle get fed and the advancements in processing (ensiling, grinding etc.) can increase the forage quality and additionally make the diet more uniform. This provides more flexibility and control to the producer during feeding. Increases in forage quality and uniformity can ultimately increase utilization of the entire forage (reduce sorting), and increase DMI and calf productivity. Limit-feeding is also an important concept to aid in preventing fattening before the cattle have a chance to grow (increase in BW and muscle). Salt inclusion in a full-feed system and directly controlling feed availability are two ways of managing a limit-feeding program (Gill, 1991).

These confined backgrounding programs also typically have fewer numbers, which allows them to focus and give special care and attention to individual animals (Peel, 2003) during the time of transition from grazing pasture with cow to being weaned and fed a ration in a bunk. During this transition calves are stressed and can be susceptible to disease.

*Increase conversion of grasslands to crop hectares*

Due to increases in corn prices in 2007 – 2008 and then again in 2011 – 2012, nearly 530 thousand ha of grass-dominated land was converted to grain production throughout the Western Corn Belt (Wright and Wimberly, 2013). In 2011, there was estimated to be approximately 37 million ha of corn planted in the U.S. with the large majority of it being grown in the Midwest. This trend of increased crop hectares still continued because based on a recent USDA report, corn hectares in 2016 were approximately 38 million ha (USDA ERS, 2017). In Nebraska alone 4 million ha, approximately 20% of the total land ha, were planted to corn in both 2011 and 2016 (USDA NASS, 2017). Despite the decrease in cash crop prices during that time span corn price was on average $6.77 per bushel in 2011 and $3.54 per bushel in 2016. This indicated that producers are reluctant to re-implement pasture land after it was converted to crop land, due to increased grain prices in the late-2000's. This change brings both challenges and opportunities for cattle producers. Although it was an initial challenge for cattle producers that needed the grass as a feed stuff for their cattle; it also provides opportunity to take advantage of cheaper forages unique to the areas saturated with row-crop farming. Additionally, most cattle producers are heavily dependent on perennial grasses that grow and are available to graze during the late-spring and summer each yr. However, they generally run into a shortage of grazing forage available in late-fall and through the winter, unless they stock pile dormant pastures or drylot their cattle and feed stored hay. Availability of corn residue however can minimize this concern, by providing a forage source to cattle producers for grazing during the late-fall and winter following grain harvest. For many decades corn residue has been a potential forage resource for cattle producers to utilize as a component of their grazing plan. Klopfenstein (1987) has concluded that grazing cattle on corn residue for a winter forage source is one of the main and most economical uses for the left over corn residue. Lamm et al. (1981) similarly stated that livestock grazing is the most economical method of recovering a portion of the energy (40% of the whole corn plant; Albert, 1971) remaining in the field after grain harvest.

*Unique integrated crop-livestock backgrounding systems in the Midwest*

In the Midwest (North and South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, and Illinois) opportunities to integrate both crop and livestock production abound. The Midwest as a whole has a strong emphasis in cash crop production (corn and soybeans) and silage. These crop ha can provide forage to the diets of beef cattle. Nebraska in particular is ranked number 3 in corn production producing 11.5% (107 million kg corn grain) of the total corn grain produced in the U.S. and is also number 2 in beef cow and calves, estimating 6.5 million cattle in Nebraska (USDA-NASS, 2016). Since a large proportion of both crop and livestock production is located in close proximity to each other, it seems only fitting to incorporate these two systems together. This would allow producers to more efficiently utilize the resources available and capitalize on potential environmental benefits, such as biological diversity, efficient nutrient cycling (livestock manure deposition), enhanced soil tilth, and soil fertility (Russelle et al., 2007). Sulc and Franzluebbers (2014) suggested livestock grazing of cover crops within cash-crop rotation or crop residue grazing are 2 commonly practiced methods of crop-livestock integration in the U.S., and are most common in the Midwest region.

There are approximately 66.8 million ha that make up the total crop ha in the Midwest, and 68.5% of those hectares are in a corn-soybean rotation. A very cheap forage source abundant in the Midwest and available to graze over the winter, is corn residue. A recent USDA-NASS (2016) report indicated that 34 million metric tons of corn grain were produced in the Midwest, resulting in 34 million metric tons of corn residue, assuming a harvest index of 0.5 (Gallagher et al., 2012). Research results have indicated that cattle are selective grazers when grazing a field of corn residue, consuming the most digestible portions first, down corn grain then followed by husk and leaf (Lamm and Ward, 1981; Fernandez-Rivera and Klopfenstein, 1989a; Gutierrez-Ornelas and Klopfenstein, 1991b). Fernandez-Rivera and Klopfenstein. (1989b) reported that both starch content and IVDMD of forage fraction of the total diet (grain and corn residue) decreased with days of grazing. Thus, it is important to graze only the down corn, husk, and leaf portions of the corn residue available, to prevent from limiting ME intake (Fernandez-Rivera and Klopfenstein, 1989b). Watson et al. (2015) suggest that utilization of 3.6 kg of forage for every 25.5 kg of grain or 14% of the total corn residue available is appropriate to maintain sufficient forage quality. Given these assumptions, it is estimated that 5 million metric tons of corn residue or 13 million AUM's (Animal Unit Months) across the Midwest are available for cattle to graze.

Corn silage production makes up only 1.1% of the total crop ha in the Midwest. However, it is an important crop, typically grown near feedlots that intend to use the corn silage as a forage source in receiving and finishing diets. In addition to production of corn silage as a feed resource, these crop hectares can also be planted to a double crop forage following corn silage harvest, and utilized for grazing in the fall and winter. When corn silage is harvested early (mid to late August), cool-season, winter sensitive grasses and brassicas can be planted immediately after to provide fall/winter grazing. Some crop producers have concerns of negative effects on soil following silage harvest, due to exposure to the environmental elements (erosion). The use of double cropped forages could prevent some of these negative environmental impacts by providing soil protection and assist in maintaining soil health (SARE/CTIC, 2016). Double cropped forages are also excellent in both yield and nutrient quality for grazing growing calves (Koch et al., 2002; Sulc and Tracy, 2007; McCartney et al., 2009).

Where the majority of corn is produced, there is typically multiple ethanol plants nearby (NASS, 2011). This is an additional advantage for the beef cattle industry in the Midwest due to the constant supply of distillers grains as a supplement to grazing cattle over the winter or as a component in backgrounding and finishing cattle diets. Distillers grains are high in protein (30% CP) especially in the form of rumen un-degradable protein (RUP), primarily due to starch removal during the milling process. Distillers grains contain approximately 68% CP as RUP and has a greater energy value (109% TDN) than corn in forage based diets (Loy et al., 2003; Benton et al., 2006). Rumen un-degradable protein by-passes degradation by microbes in the rumen, and makes it to the small intestine where it is digested and absorbed through the rumen wall as an amino acid (AA). These AA are used by peripheral tissue and the liver, but any excess AA are deaminated and the carbon skeleton product can enter the TCA cycle through many different avenues along the TCA cycle depending on the structure and number of carbons associated with the particular AA. At this point the AA is used to create energy if in a growing or active state or stored as adipose tissue in a fattening or mature state. The combination of cheaper forage sources (corn residue) and readily available supplements (distillers grains) make the Midwest a premier location for backgrounding young growing calves after weaning, and before entering the feedlot.

**Grazing Corn Residue**

Sulc and Franzluebbers (2014) indicated that grazing corn residue after grain harvest is one of the simplest and most economical integration methods. Additionally, some studies have indicated that grazing only removes 5 to 25% of soil surface cover (Clark et al., 2004; Lesoing et al, 1996). Therefore leaving enough cover to prevent wind and water soil erosion. Soil compaction however is still a concern for crop producers, but research has demonstrated that soil compaction would be minimized if implementing the following guidelines: 1) avoid grazing when the soil is either wet or thawed, 2) keep in mind that multiple freeze-thaw cycles in the soil will lessen soil surface compaction, and 3) stock cattle appropriately to only remove 3 kg of residue per every 25.5 kg of grain (Clark et al., 2004; Maughan et al., 2009; Rakkar et al., 2016).

*Predicted current grazing of corn residue*

Schmer et al. (2017) indicated that 52% of the total corn residue in Nebraska was grazed. According to this survey, Nebraska was ranked number one in corn residue grazing at 1.91 million ha. Iowa was ranked second with only 385,000 ha of corn residue being grazed. Due to greater cow inventory in western Nebraska, it is estimated that more corn residue hectares are grazed in western than in eastern, Nebraska (personal communication, Rasby 2016). McGee (2013) stated that majority of corn residue in the Midwest is grazed by mature cows in the fall/winter (October to February). In eastern Nebraska it may be advantageous to graze growing calves on this corn residue rather than mature cows to decrease transportation cost and add an extra source of income or additional enterprise to the already existing operation. However, depending on the ownership of the calves, it may also be difficult to find individuals to manage calves while grazing corn residue in eastern Nebraska, especially since supplementation is needed. Given that land management decision are often made by crop producers, it can also be postulated that concerns of negatively impacting soil characteristics or subsequent grain yields is a barrier to grazing residue in eastern Nebraska. However, research suggests, grazing corn residue has little to no impact on the subsequent yr grain (corn/soybean) yields (Clark et al., 2004; Tracy and Zhang, 2008; Drewnoski et al., 2016; Rakkar et al., 2016) and that implementing an integrated crop-livestock system by grazing corn residue is potentially beneficial in diversifying farm ecosystems and increasing production efficiency (Sulc et al. 2007).

*Typical corn harvest index, residue yield, and residue quality*

The harvest index is the proportion of grain yield to the total amount of above ground corn plant biomass (grain, husk, leaf, cob, and stalk; Prince et al., 2001). It can be calculated by dividing the mass of corn grain by the sum of the mass of corn grain and plant residue. A common harvest index 0.45 to 0.55 times the corn grain yield (kg/ha) can be used by producers to estimate the amount of above ground forage remaining in the field (Gallagher and Baumes, 2012). In a recent study conducted in 6 different locations across Nebraska reported that corn grain yields ranged from 9,543 to 17,387 kg/ha and corn residue yields ranged from 5,864 to 11,740 kg DM/ha (Ulmer et al., 2016). They also reported an average harvest indexes of 61.5%. It is important to note that one of the locations were rain-fed (dryland), one location had a sub-surface drip irrigation, and the remaining 4 locations were irrigated using a pivot.

When grazing corn residue, cattle select the most digestible portions first: corn grain, husk, and leaf (Lamm et al., 1981). They determined this by collecting corn residue in the fall prior to grazing (initial residue mass = 6,212 kg DM/ha and in late winter after grazing had occurred for 86 d (post grazing residue mass = 3,099 kg DM/ha). In the pre-grazing sampling date 4 plant parts consisting of grain, cobs, husk/leaf, and stalk made up 11.2, 9.1, 39.0, and

40.7% on a DM basis, respectively. Whereas in the post-grazing sampling date these same plant parts made up 1.4, 13.1, 30.6, and 54.8% on a DM basis, respectively (Lamm et al., 1981). Cob and stalk are typically overlooked by grazing cattle unless forced to graze past consumption of most the husk and leaf material (Fernandez-Rivera and Klopfenstein, 1989b; Gutierrez-Ornelas and Klopfenstein, 1991a; Wilson et al., 2004). Fernandez-Rivera and Klopfenstein (1989a) used esophageally fistulated steers to evaluate the diet of cattle grazing corn residue over 56 d. They found that CP of the diet gradually decreases from approximately 7.8% to 5.8% within the first 4-5 wk of grazing and then leveled off at 5.8% throughout the rest of the grazing period on irrigated fields. Intake also decreased from 8.54 kg/d to 6.70 kg/d over the course of the grazing period. Using this information, the University of Nebraska developed a grazing recommendation that targets the removal of half the husk and leaf in a corn residue field (Rasby et al., 2014). If producers follow this recommendation only 3.0 kg of residue is consumed for every 25.5 kg of corn produced; which is equivalent to approximately 24% of the corn residue removed, using a harvest index of .5.

One of the greatest challenges of corn residue as a forage source is its poor digestibility and protein content (Klopfenstein, 1987). Grain availability within the first few wk of grazing is an excellent source of CP (12.6%) and energy (95.2% IVOMD) (Lamm et al., 1981). When only comparing the forage component of the corn plant, husk and leaf have the greatest digestibility (IVDMD) ranging from 44.9 to 60.5% and 39.8 to 51.6%, respectively; and the greatest CP ranging from 3.3 to 7.8% and 3.7 to 8.7%, respectively (Watson et al., 2015). More recently, 2 studies reported that total tract digestibility of husk, when fed to crossbred, wether lambs was 68% of OM (McPhillips et al., 2016) and 70% of OM (Updike et al., 2016). Husk fed to wethers were obtained after seed corn harvest.

*Supplementation to growing calves while grazing corn residue*

Grazing corn residue alone will not meet the growth requirements for maintenance of growing calves, based on a recent experiment conducted by Tibbitts et al. (2016) that observed an ADG of -0.08 kg when grazing corn residue over the winter, without supplementation. Steers in this study grazed corn residue at a stocking rate of 3.6 kg of corn residue per every 25.5 kg of grain. According to multiple studies it is suggested that protein, is the first limiting nutrient of growing calves grazing corn residue (Fernandez-Rivera and Klopfenstein, 1989b; Wilson et al., 2004; Tibbitts et al., 2016; Welchons and MacDonald, 2017). Supplementation of dried distillers grains plus solubles (DDGS) can provide needed RDP to allow for digestion of the corn residue as well as provide RUP (68% of CP) to meet MP needs (Gillespie-Lewis et al., 2015; Tibbitts et al., 2016; Welchons and MacDonald, 2017). Wilson et al. (2004) concluded that approximately 0.16 kg/d of supplemental RUP (0.77 kg/d of DDGS) is at least needed to meet maintenance requirements of growing calves while grazing corn residue during the winter. When fed above this level a positive linear relationship of calf ADG response to increasing levels of DDGS supplementation when grazing corn residue has been well documented (Watson et al., 2015; Welchons and MacDonald, 2017).

*Effect of grazing on soil properties and subsequent grain yields*

For crop producers, maintaining soil structure and soil organic matter it is important to ensure maximal grain yields. Much of the crop land and thus corn residue is under the control of producers that specialize in crop production, but do not own cattle. Thus it is important to carefully evaluate the effects of grazing corn residue on soil properties, such as erosion potential, soil moisture and temperature, soil compaction, and soil organic matter.

Nelson (2002) indicated that most, if not all of agriculture cropland within the U.S. has experienced some level of soil erosion each yr. The paper mentioned that rainfall erosion primarily in the form of sheet and rill erosion, is first initiated by rain drops directly hitting the soil surface (splash erosion), dislodging the top layer of soil particles (Nelson, 2002). Splash erosion is the least severe stage, but it is followed by sheet erosion which involves soil movement by overland flow and finally rill erosion which refers to small, temporary water flow paths on hillslopes (FAO, 1965; Zachar, 1982; Nearing et al., 1997; Toy et al., 2002). Wind erosion occurs by suspending soil particles above the field surface or can be combined with the initial splash erosion, at the time soil particles are dislodged into the air (Nelson, 2002). Wienhold et al. (2010) counted the incidents of corn residue covering the soil at every 1 m along a 100 m transect line to calculate the percentage of the soil covered by residue. They stated that runoff initiation was much quicker (196 s vs. 240 s) and greater amounts of soil were lost (0.36 Mg/ha vs. 0.27 Mg/ha) when comparing plots with residue removed (50% cover) to plots with residue retained (77% cover). Ulmer et al. (2016) reported that grazing at the recommend stocking rate of 50% removal of husk and leaf (12% of total residue) resulted in on average 86% residue cover remaining in the spring from 6 different locations across Nebraska suggesting that grazing would not significantly increase erosion risk.

Sulc and Franzluebbers (2014) concluded in a review of integrated cropping systems that grazing's impact on the top layer of the soils surface is the main concern. Studies regarding the effects of cattle grazing on cropland, reported varying results on soil compaction (Mullins and Brumster, 1997; Clark et al., 2004; Tracy and Zhang, 2008). In a three yr study in Iowa when cows grazed corn residue at a stocking rate of 3.7 cows per ha from October to February and were moved to a new paddock each month increased penetration resistance at a depth of 10 cm for paddocks that were grazed in October and November was observed (Clark et al., 2004). However, soil bulk density was not affected. When soybean yields of grazed and un-grazed areas were compared, there was one incident (out of 15) in which the grazing reduced soybean yield (2775 vs. 3012 kg/ha for grazing and un-grazed, respectively). During this period the soil was wet and the ground was not frozen. They concluded that a reduction in subsequent soybean yields would be minimal if cattle were grazed during periods when the soil was frozen. Similarly Tracy and Zhang (2008) in Illinois reported increased penetration resistance in both yr of a 2 yr study, in grazed sections of corn residue that were stocked at 1 cow/ha from November to March, but reported no negative effects on subsequent corn yield. The cropland was managed in a continuous corn system and was chisel plowed with spring tillage. It is important to note, that tillage of the soil would disturb the soil structure and leave the soil susceptible to be compacted, whereas no-till management will allow the soil to maintain its structure and thus be less susceptible to compaction. In a long-term study (16 yr) conducted in Nebraska fall grazing had no effect on soil penetration resistance (Rakkar et al., 2016). Grazing in this experiment occurred from November to January with a targeted removal of 3 kg of residue per every 25.5 kg of grain (Rakkar et al., 2016). The land was managed in a corn-soybean rotation and subsequent soybean yields were increased due to grazing.

## Grazing Double Crop Forages

### *Advantages of double crop forages*

Double crop annual forages otherwise commonly referred to as cover crops, have increased in popularity over the last few yr (SARE/CTIC, 2016). The use of cover crops are primarily implemented from a crop producer’s point of view to improve soil conservation, soil structure, weed control, and nutrient cycling (Sulc and Tracy, 2007; Sulc and Franzluebbers, 2014; SARE/CTIC, 2016). Although labor and cost involved with planting and managing cover crops is perceived as major challenge by producers (Drewnoski et al., 2015). Grazing is one way to offset the costs of planting cover crops while still potentially gaining the conservation benefits (Franzluebbers, 2007).

There are many ways that double crop forages can be implemented after different cropping systems in the Midwest (Sulc and Franzluebbers, 2014) and specifically in Nebraska (Drewnoski et al., 2015). Some examples of implementing double cropped forages include: after summer hail damage (early- to mid-summer), winter wheat harvest (mid-summer), seed corn harvest (mid- to late-summer), corn silage harvest (late-summer to early-fall), or soybean harvest (mid-fall). For early and mid-summer planting, cool-season small cereal grasses and brassicas can provide high quality forage that can be used for grazing backgrounding calves through the fall and winter (Smart et al., 2006; Ulmer et al., 2017).

A major challenge in encouraging crop producers to allow this type of integration, is their concern of negative effects on soil properties and subsequent grain yields due to grazing of the cover crop (Sulc and Franzluebbers, 2014). In Alabama, when cows and calves grazed fall planted wheat from late-January to April, prior to planting cotton in the end of April; they observed increased soil penetration resistance on a Decatur silt loam field and a decrease in subsequent cotton yield by 14%, (Mullins and Brumester, 1997). The occurrence of compaction under these circumstances is not unlikely due to this study being located in the Southeastern U.S. where temperatures do not get very cold during the winter and it was unlikely that the ground was frozen during grazing. Studies conducted in Illinois, also indicated that grazing double crop forages over the winter did increase soil penetration resistance indicating that some compaction did occur. However, soil aggregate stability in water, subsequent corn grain yield (6% greater), and soil organic C all increased after grazing cover crops (Maughan et al., 2009; Tracy and Zhang, 2008). Suggesting that integration of cover crops and grazed by cattle during the winter on frozen soils had mostly positive effects on subsequent grain yields, and was encouraged to implement.

*Typical yield and forage quality*

One of the main things to consider when estimating or evaluating yield of double crop annual forages is the planting date. Planting in late summer may limit the yield potential of these forages, due to fewer growing degree days (Wiedenhoeft and Barton, 1994). However, forages from these later planting dates are more likely to be less mature and thus higher quality (Wiedenhoeft and Barton, 1994).

The suggested theory that forage yields increase and nutritive value decreases with earlier planting dates and more mature plants, holds true for oats in a study conducted by Coblentz et al. (2011 and 2012) in Wisconsin. Oats (*Avena sativa L.*) were planted on July 15, August 1, and August 15, and harvested on 5 different dates between September 15 and November 15. The July 15 planting date resulted in the greatest yields from 4,501 to 8,100 kg/ha, which linearly and quadratically increased over time, as observed by harvesting at different harvest dates (Coblentz et al., 2011). Whereas the August 1 planting date had a linear increase in forage yield over time, and reached a maximum of 5,175 kg/ha by the November 15 harvest date. The mid-August planting date greatly reduced DM yield of oats compared to the earlier planting dates, and the overall DM yield never exceeded 1,934 kg/ha (Coblentz et al., 2011). In a corresponding paper, they analyzed the nutrient content of oats planted on the 3 different dates (Coblentz et al., 2012). They concluded from this study that 48 h in vitro neutral detergent fiber digestibility (NDFD) and 48 h total digestibility decreased over time and was least for the earlier planting dates.

Ranges from the initial harvest date (September 15) to the final harvest date (November 15) for NDFD of each planting date are as follows: 548 to 416 g/kg for July 15, 704 to 529 g/kg for August 1, and 798 to 665 g/kg for August 15. These results by Coblentz et al. (2011 and 2012) indicate that oat forages typically have increased DM yields, but poorer nutritive value with earlier planted and more mature oats; which was previously concluded by Wiedenhoeft and Barton (1994).

Villalobos and Brummer (2015) in Fort Collins, CO evaluated the forage yield and nutritive value of turnip (*Brassica rapa*) and radish (*Raphanus sativus*) leaf planted in either late-July or mid-August and harvested in either mid-October or mid-November. They concluded that delaying planting date until mid-August caused a reduction of 2,027 kg/ha for turnips and reduced radish yields by 3,573 kg/ha. However, turnip and radish leaf CP content were not different between the 2 planting dates (20.8 and 21.0%). In vitro true digestibility (IVTD) was not different for turnip leaf when planted or harvested at both time points (90.8%), but radish leaf appeared to have a greater IVTD when harvested earlier (91.1%) than later (85.5%). This difference between oats and brassicas nutritive value at different maturity levels, indicates that oats do decrease in nutritive value when plant maturity increases, but this probably not the case in regards to brassicas nutritive value. Since brassica nutritive value appears to maintain at a similar level, despite a 2 to 3 wk difference in maturity.

Koch et al. (2002) in Powell, Wyoming, planted turnip and radish in early-August and collected samples in mid-October. They reported initial forage yields of 2,082 kg/ha for turnip leaf and 2,972 kg/ha for radish leaf. In regards to turnip leaf they reported CP at 12.1%, ADF at 15.5%, NDF at 22.3%, and IVDMD at 85.9%. Koch et al. (2002) also indicated that 25% of the turnip root was above ground and could be removed by pulling the leaf portion as long as the ground was not frozen. Thus, it is reasonable to include root in available forage yield calculations as previous work has shown turnip root to be palatable and nutritious for grazing animals (Rook, 1998; Koch et al., 2002). They reported turnip root yield (1981 kg/ha) and nutrient values and indicated that root had less CP (9.6%), ADF (12.4%), and NDF (18.3%), but had greater IVDMD (89.1%) when compared to the turnip leaf. Radish leaf nutritive values were also reported, with CP at 11.0%, ADF at 18.8%, NDF at 26.3%, and IVDMD at 85.8%.

An additional characteristic unique to brassica forages is the elevated concentrations of highly fermentable carbohydrates (Barry, 2013). In New Zealand, Westwood and Mulcock (2012) planted 2 yr of turnips in October and harvested them 53 d and 95 d following planting. They reported water soluble carbohydrates (WSC) at 19.2% for turnip leaf when harvested on the first date and 23.3% when harvest on the second date. They also indicated that turnip roots had even greater WSC levels at 28.1% when harvested 53 d following planting, than the leaf component. Values for turnip root were not reported for the 95 d harvest date. Therefore, when considering grazing, it is important to be aware of the potential for acidosis in ruminants when consuming brassicas, due to the elevated levels of WSC, and their ability to be fermented very quickly in the rumen (Westwood and Mulcock, 2012). Oats on the other hand have lesser levels of WSC than brassicas, as indicated by Coblentz et al. (2015) that observed a range of WSC from 4.3 to 15.1% when planted in mid-August and harvested on weekly intervals from September 30 to November 27. The elevated levels of fiber in oats, which slow down rumen passage rate and protein and WSC in brassicas, which increase rumen digestibility, complement each other well in ruminant animal diets.

*Grazing double crop forages*

Koch et al. (2002) observed no difference in ADG when comparing Columbia-Rambouillet crossbred lambs (37.6 kg) solely grazing turnips or radish from October 24 to January 15 to lambs (37.4 kg) feed a feedlot diet (35% corn, 35% barley, and 30% alfalfa hay) (0.14, 0.15, and 0.15 kg/d, respectively). The turnip and radish pastures in the Koch et al. (2002) study was planted in early-August and initial forage yield, including leaf and root was 4,063 kg/ha and 4,139 kg/ha, respectively. All lambs remained in their respective treatments all the way through finishing until slaughter. Additionally, they observed no difference in carcass weight (24.7 kg), YG (1.6), or fat depth (0.12 cm) among the 3 treatments. These results give some indication of the elevated digestibility and energy value of brassicas in order to finish lambs on these diets and observe no difference when compared to lambs consuming a typical finishing diet. Likewise in a similarly designed study, 7 mo old ewe lambs (38.2 kg), were not different in ADG (0.16 kg/d) between lambs grazing radish, lambs grazing turnips, and lambs in a feedlot fed a 35% corn, 35% barley, and 30% alfalfa hay diet (Yun et al., 1999). Yun et al. (1999) also reported similar fat streaking (5.6; 5 = small and 6 = modest) and confirmation scores (10.9; 10-12 = choice) among lambs grazing turnips, lambs grazing radish, and lambs fed in a feedlot. Concluding that lambs grazing radish and turnip produced carcasses with acceptable yield and quality grades (Yun et al., 1999).

There is very little research regarding performance and carcass characteristics of cattle grazing monocultures of oats and brassica or mixtures of these forages. Smart et al. (2006) in Brookings, SD, evaluated growing performance of heifers (233 kg) grazing either a solely rye pasture or a rye and turnip mix at a stocking rate of 5.4 heifers/ha. Forage was planted on either August 1 or August 15 and species (rye and turnip) were analyzed separately at harvest. They reported yields for the first planting date 902 kg/ha and 1,787 kg/ha (rye and turnip, respectively); whereas yields for the second planting date were 560 kg/ha and 953 kg/ha (rye and turnip, respectively). They reported greater ADG for heifers, solely grazing rye (0.73 kg/d) than heifers grazing the rye and turnip mix (0.56 kg/d) after 63 d of grazing, starting in late-September. Similar rates of gain (ADG of 0.59 kg/d) were observed for steers (213 kg) grazing an oat monoculture planted on September 9$^{th}$ in Eastern Nebraska over a 62 d period in November and December at a stocking rate of 0.69 steers/ha (allocating 794 kg of DM per steer) (Ulmer et al., 2017). These results suggest that relatively good gains can be expected for backgrounding calves, unfortunately no studies that have looked at the effects grazing these forages have on subsequent finishing phase performance or carcass characteristics.

**Growing Phase Factors Effecting Finishing Performance and Carcass Characteristics**

*Weight measurement concerns*

The common way of measuring growth or ADG is by determining the live BW change of an animal from a start weight at a particular time point of interest (birth, beginning of growing phase, beginning of finishing phase, etc.) to a final weight (weaning, end of growing phase, final finishing BW, etc.) and dividing by the number of days between those live weights of interest. However, Owens et al (1993) concludes that full live BW measurements are imprecise, inaccurate and often a biased predictor of changes in lean body mass. Live BW measurements and gain calculation can be deceiving depending on how it was taken, primarily due to variation in rumen fill. Changing diet types and intake variability among animals can alter the weight of digesta significantly, and if not adjusted for, this weight change alone can fully account for the differences observed in growth between different treatments, consuming different diets (Tolley et al., 1988). Williams et al. (1992) also supported this statement by reporting that changes in digestive tract contents can occur within minutes or days. Differences that diet can have on rumen fill are observed when comparing a yearling that’s diet primarily consists of forage (grazing or fed forage) and a calf-fed that consumes a diet mostly containing concentrates. Forages are bulkier, take more time to digest, and pass through the digestive system at a much slower rate than concentrates. Forages are also less energy dense than concentrates, therefore when an animal eats forage it has to consume enough to attempt at meeting their energy needs; which leads to greater DMI and also limiting DMI due to rumen fill, when consuming a forage diet rather than a primarily concentrate diet. Ultimately calves consuming a forage based diet that contains elevated levels of NDF have an increased live BW due to increased rumen fill, if not accounted for properly.

Two methods of attempting to mitigate the variation in live BW due to differences in rumen fill and variation among calves in treatments, without having to slaughter the animal are: measuring live shrunk BW or taking weight measurements on consecutive days. Live shrunk BW is measured by removing the availability of feed and water to calves for a period of time, typically 12 hr (but time can vary) before taking a BW measurement (Owens et al., 1995). This food and water restriction will reduce the variation of digesta in the gastrointestinal tract, however the amount of time withdrawn from feed and water and the diet type (fiber or starch) previously consumed can affect the success of this method. Owens et al. (1995) also indicated that with holding feed and water from animals for an extended period of time can disrupt the feeding schedule that cattle are accustom to and can complicate the realiment process after taking the shrunk BW. Incidents of hungry calves over indulging in feed can consequently result in acidosis, especially if the calves are provided a high-concentrate diet at realiment. Another method of reducing rumen fill variation without disrupting the normal feeding behavior of the steers, is to provide all calves a similar diet for 5 consecutive d, and take 2 consecutive d weights (Stock et al., 1983; Watson et al., 2013). There can be some flaws in this method though depending on the diet that calves were previously consuming. It has been reported that previously restricted steers or steers previously consuming a primarily forage diet will subsequently have greater DMI than steers previously on a concentrate diet, when both sets of calves are provided the same diet with ad libitum access (Murray et al., 1977; Owens et al., 1995; McCurdy et al., 2010). It is important to manage cattle similarly when taking every weight measurement, with one of the strategies being limit feed a common diet when taking consecutive BW measurements to eliminate the variation in rumen fill.

Empty BW (EBW) measurements collected by serial slaughter of random calves from each treatment at the different time points of interest (start of growing phase, end of growing phase/start of finishing phase, and final weight) or using final HCW to estimate final EBW are additional ways to eliminate the variation in rumen fill. Measuring EBW directly determines the rumen fill weight accounting for live BW by getting an exact weight of digesta at slaughter (Owens et al., 1995). However this process can be very labor intensive and reduces the number of calves in a study, which may alter statistical analysis. There have also been attempts at trying to create a regression equation to calculate EBW using live BW (NRC, 1984; Williams et al., 1992; NRBC, 2016), but differences in diet type and animal maturity can greatly alter the preciseness of this estimate (Williams et al., 1992; Owens et al., 1995). Using HCW at final slaughter to estimate final EBW or final shrunk live BW can also be calculated by dividing the HCW by an average dressing percentage of all of the calves (Owens et al., 1995). This method of calculating shrunk live BW has been reported to remove approximately 20% of the variation due to rumen fill, than measuring shrunk live BW by withdrawing the calves from feed and water

(Van Koevering et al., 1995). All of these methods should be considered and at least one method implemented when measuring BW and attempting to confidently report ADG differences or lack of differences due to treatments in scientific studies; because if the growth reported does not represent lean carcass mass, then it should be considered irrelevant (Owens et al., 1993).

*Compensatory growth*

Compensatory growth is one trait that cattle feeders tend to associate with previously restricted, backgrounded cattle. Owens et al. (1993) explained this phenomenon, as previously backgrounded animals undergoing diet restrictions, usually have greater gains during the realimentation or finishing phase than similar animals that have never been restricted. The concept of determining a growing gain threshold level in order to observe subsequent finishing compensatory growth has been discussed, but not actually discovered; although many researchers have studied the reasons and mechanisms behind why this compensatory gain phenomenon occurs (Tolley et al, 1988; Carstens et al., 1991; Drouillard et al., 1991; Owens et al., 1993; Hornick et al., 2000; Klopfenstein et al., 2000; Reuter and Beck, 2012). Results from multiple compiled studies in Nebraska however, concluded that previously restricted cattle for different rates of gain (.57 or .84 kg/d) over the winter and summer grazing, only compensated for 19 to 88% of their previous restriction when unrestricted and provided a common finishing ration (Klopfenstein et al., 2000). Morgan and Holmes (1978) and Hogg (1991) concluded in reviews that the overall amount of compensatory growth depends on multiple factors, including: age during nutrient restriction, restriction severity, duration of restriction, and the type of malnutrition (energy or protein), the realimentation diet type and timing, and the animals breed type. A combination of these factors may explain some of the variation observed for the amount of compensation after realiment during the Klopfenstein et al. (2000) study.

It is thought that when previously restricted cattle are provided with an ad libitum, greater nutrient diet then they experience rapid hypertrophy lean muscle growth, before accreting adipose tissue through hyperplasia (Smith et al., 1977; Rompala et al., 1985; Mader et al., 1989; Owens et al., 1993; Pethick et al., 2004). If an animal is experiencing compensatory growth then it is expected that their net energy requirements for growth are reduced by 11 to 18% due to accumulation of lean protein (NRC, 1984; Carstens et al., 1991). This connection makes logical sense, when considering that lean protein is less energy dense and contains more water weight (Carstens et al., 1991), which would contribute to the extra gain exhibited by calves experiencing compensatory growth. When Carstens et al. (1991) conducted a serial slaughter taking separate weights of the hide head, shank, flushed digesta contents, digestive tract, pluck (kidney, liver, heart-lung-trachea), and the empty carcass; these results indicated that lean protein accumulation made-up the majority of empty body growth, for steers experiencing compensatory growth after a period of restriction (.4 kg/d, gain) due to intake restriction for 200 d. For these same steers undergoing compensatory growth, non-carcass protein (digestive tract and liver) consisted of the most growth on a percent of EBW basis. During the realiment phase the steers were provided the same 70% concentrate diet as they were in the restricted phase, but were allowed to consume it ad libitum. These results follow suit with the findings of McBride and Kelly (1990) which indicated that the digestive tract alone accounted for 28 to 46% of the entire body’s protein synthesis, in growing calves at approximately 300 d of age.

Some studies have concluded that if steers are experiencing compensatory growth, then they will have leaner carcasses at slaughter (Smith et al., 1977; Carstens et al., 1991). These studies either fed to a prior set number of days (Smith et al., 1977) or a similar final BW, instead of feeding to a common back fat thickness, which could have confounded their results.

Klopfenstein et al. (1999) observed that most industry producers use rib fat depth as an indicator of marbling (i.e. finishing). This study went on to further state that since marbling and fat depth both increase with time on feed, then it is only logical to feed cattle of different backgrounding systems to an equal fat depth (Klopfenstein et al., 1999). Owens et al. (1993) indicates that backgrounding cattle, shifts their mature BW up by increasing the accretion of protein mass. Owens et al. (1993), defines mature BW as the point of maximum protein mass, despite an increase in overall EBW due to fat deposition if cattle are continued to be fed past maximum protein accretion. Therefore in order for previously restricted cattle to be fed to a similar degree of finishing, they must be fed to a common back fat thickness. Feeding to a common back fat end point, typically also results in backgrounded cattle or previously nutrient restricted cattle having a heavier final BW than cattle not previously restricted in the growing phase. Other studies that also fed cattle to a common finishing end point, indicated that lean muscle accretion during compensatory growth only occurs in the beginning of the realiment phase, but eventually consumed Net Energy of gain ($NE_g$) stops contributing to protein synthesis and begins fat de novo synthesis (Fox et al., 1972; Rompala et al., 1985; McCurdy et al., 2010). The majority of these studies indicate restricted nutrition alters the body composition most during growth, but minimal differences are observed when cattle are fed to a common 12$^{th}$ rib fat endpoint (Owens et al., 1995; McCurdy et al., 2010).

*Effect of feedlot placement BW (calf-fed vs. yearling)*

Varying backgrounding systems provide cattle producers or cattle feeders with flexibility. It allows them to increase the number of head they can hold, spread out the timing of feeding and slaughter throughout the yr, and gives them the ability to adjust according to market prices and trends. It also can be used to increase frame size of smaller framed calves before entering the finishing phase, and ultimately increasing the calves HCW (Owens et al., 1993).

Three possible avenues for management of calves weaned in the fall are: 1) calves are placed directly in the feedlot and adapted to a high-concentrate diet (calf-fed), 2) calves either graze or are fed a high-forage based diet for 3 to 5 mo (short-yearling) and then transitioned to high-concentrate diet, or 3) short-yearling continue on a forage based diet for an additional 4 to 5 mo and are then adapted to high-concentrate diet (long-yearlings). Most studies have reported greater ADG and DMI, but less G:F during the finishing phase for both short and long yearlings when compared to calf-feds (Griffin et al., 2007; Lancaster et al., 2014). Griffin et al. (2007) sorted calves after purchase from a sale barn in the fall, into a group of heavy (292 kg) and group of light calves (239 kg). Feedlot placement BW was consequently heavier for yearlings (435 kg) than calf-feds (291 kg) (Griffin et al., 2007). All calves went through a 21 d receiving period, in which they were vaccinated and implanted during that time before the trials started. Heavy calves were assigned to the calf-fed treatment, and were fed a diet containing 40% wet corn gluten feed (WCGF) and 45% dry rolled corn for 168 d (gain: 1.97 kg/d); whereas light calves were placed in a long-yearling system, which included grazing corn residue and supplemented WCGF (2.27 kg/steer/d) over the winter (gain: 0.68 kg/d) and grazed bromegrass pasture from April 20 to mid-May (summer gains not mentioned), before finishing on the 40% WCGF and 45% dry rolled corn diet for 90 d in the drylot. All calves were fed to an equal back fat endpoint. Results from 8 yr of compiled data comparing calf-feds versus long-yearlings indicated that long-yearlings had greater finishing DMI than calf-feds, but calf-feds took an additional 78 d on feed to finish (Griffin et al., 2007. Therefore, overall calf-feds consumed 23% more feed during the finishing phase than long-yearlings. Long-yearlings did exhibit some compensatory growth with greater finishing phase gains (2.06 kg/d) than calf-feds (1.73 kg/d). Long-yearlings were also heavier at the end of the finishing phase than calf-feds (620 and 582 kg, respectively), due to starting at a heavier placement BW and having greater finishing phase ADG. However, calf-feds were 19% more feed efficient during the finishing phase than long-yearlings (0.178 and 0.150 kg/kg, respectively). A meta-analysis by Lancaster et al. (2014) analyzed 10 different studies comparing calves that were adapted to a high grain diet shortly after weaning (calf-feds) to calves that had been backgrounded over the winter (short yearlings) and some also grazed over the summer before finishing (long yearlings). The yearling systems consisted of grazing wheat pasture, winter grazing low quality forages followed by summer grazing, fed a silage or hay-based growing diet, or limit-fed a high-concentrate diet; thus indicating that the "yearling" category consisted of both short and long yearlings. All calves had been weaned between 6 and 8 mo of age, no early weaned treatments were included in the analysis. Regression models were created to evaluate finishing performance differences between yearlings and calf-feds. Results from this comparison were similar to results from the Griffin et al. (2007) study, and concluded that feedlot placement BW was greater for yearlings (367 kg) than calf-feds (251 kg). Finishing DMI, ADG, and final BW was also greater for yearlings (11.5 kg/d, 1.71 kg/d, and 555 kg, respectively) than calf-feds (8.5 kg/d, 1.52 kg/d, and 529 kg, respectively). Additionally, G:F in the Lancaster et al. (2014) meta-analysis was nearly identical to results from the Griffin et al. (2007) study, with calf-feds (0.178 kg/kg) having greater G:F than yearlings (0.157 kg/kg).

Conversely from the 2 previously mentioned studies, Sainz et al. (1995) reported greater finishing phase G:F for yearlings than calf-feds, when consuming a common finishing diet. They evaluated 3 systems: 1) yearlings limit-fed a high-concentrate diet (CL) during the growing phase, 2) yearlings consuming an ad libitum forage based diet (FA) during the growing phase, and 3) calf-feds on an ad libitum, high-concentrate diet (CA). The calf-feds started the finishing diet following a 3 wk adaptation period and lasted 153 d. Whereas the growing phase for yearlings lasted 112 d and the finishing phase lasted 89 d for the CL steers and 111 d for the FA steers. All steers were fed to a similar final BW, which averaged 497 kg. Overall gains for calf-feds were 1.51 kg/d, whereas CL and FA steers had similar growing phase ADG (0.69 and 0.77 kg/d, respectively). It is important to note that during the growing phase calves fed an ad libitum forage diet and calves fed an ad libitum grain based diet had the same DMI (8.41 kg/d, for both treatments). This would have potentially caused the calves consuming the forage diet to have a similar visceral or GI tract size to the calf-feds.Finishing phase DMI was greater for the 2 yearling treatments FA and CL (11.7 and 11.0 kg/d, respectively) than the CA treatment (9.0 kg/d). Finishing ADG was greatest for the CL steers (1.92 kg/d), followed by the FA steers (1.74 kg/d), and least for the CA steers (1.51 kg/d). The boost in finishing gain ultimately caused the backgrounded calves on the limit fed grain diet and ad libitum forage based diet to have a greater feed efficiency (Sainz et al., 1995). Yearlings limit-fed a high-concentrate diet (CL) during the growing phase had the greatest subsequent finishing G:F (0.175 kg/kg), followed by yearlings consuming an ad libitum forage based diet (FA) during the growing phase (0.147 kg/kg), and least for calf-feds on an ad libitum, high-concentrate diet (CA) (0.134 kg/kg).

Similarly results were reported by Vasconcelos et al. (2009) that also evaluated 3 similar systems: 1) steers during the growing phase fed an ad libitum high-forage diet (AF), steers during the growing phase provided an ad libitum high-concentrate diet (AC), and steers limit-fed a high-concentrate diet (LC). The calf-feds started the finishing diet following a 2 wk adaptation period and lasted 140 d. The growing phase for yearlings lasted 56 d and the finishing phase lasted 84 d. All steers were slaughtered after 140 d of the trail. Overall gains for calf-feds were

1.95 kg/d, whereas LC and AF steers had similar growing phase ADG (1.51 and 1.86 kg/d, respectively). Limit feeding the high-concentrate diet would explain why that treatment had decreased DMI (10.3 kg/d) during the finishing phase, but still observe compensatory growth (1.75 kg/d) during the finishing phase, resulting in increased G:F. However steers consuming the AF diet also had greater G:F than the steers on the ad libitum high-concentrate diet. This difference is mostly explained by the unusually elevated intake of the AC steers in the finishing phase (11.6 kg/d), without increasing finishing phase ADG (1.70 kg/d) compared to ADG (1.88 kg/d) for the AF steers. They indicated that AF steers or LC steers had greater G:F (0.177 and 0.179 kg/kg) during the finishing phase consuming a common finishing diet, than AC steers (0.156 kg/kg).

A concern of both of these studies however is that they separated out the a growing (56 d) and finishing (84 d) phase for the calf-feds (CA: Sainz et al., 1995 and AC: Vasconcelos et al., 2009) although they were consuming the high-concentrate diet at ad libitum the entire time of the study. Therefore, to truly compare the entire finishing period G:F for each treatment, it is important to compare the entire finishing phase (153 d: Sainz et al., 1995 and 140 d: Vasconcelos et al., 2009) G:F for the calf-fed steers to the finishing phase for the ad libitum forage and limit-fed concentrate steers (111 d: Sainz et al., 1995 and 84 d: Vasconcelos et al., 2009). Resulting in this case, CA and CL steers (0.173 and 0.175 kg/kg, respectively) having greater G:F than FA steers (0.147 kg/kg) (Sainz et al., 1995). A similarly trend was observed in the Vasconcelos et al. (2009) study, in which G:F for the AC steers (0.183 kg/kg) during the entire finishing phase was greater than the finishing phase (84 d) G:F for the AF and LC steers (0.177 and 0.179 kg/kg, respectively). All G:F values were actually reported in the table of both papers, not calculated.

These G:F results when comparing the treatments this way are more similar to the results of Griffin et al. (2007) and Lancaster et al. (2014).

There have been many conflicting results regarding the effect of calf-fed or yearling system on carcass characteristics. The Griffin et al. (2007) and Lancaster et al. (2014) studies that were described earlier had relatively similar results regarding carcass characteristics. Calves in the Griffin et al. (2007) trial started the finishing phase at different live BW, long-yearlings (435 kg) were 143 kg heavier at feedlot placement than calf-feds (291 kg). Long-yearlings were also heavier at the end of the finishing phase than calf-feds (620 and 582 kg, respectively), due to starting at a heavier placement weight and having greater finishing phase ADG. It is important to clarify that all steers in this data set were fed to an equal back fat endpoint. Carcass results from this data set concluded that similarly to their final BW differences, long-yearlings had greater HCW (390 kg) than calf-feds (367 kg). Calf-feds did have a greater back fat thickness (1.35 cm) than long-yearlings (1.20 cm), despite their attempts to feed all steers to a common back fat thickness. However YG (2.66) and marbling scores (518) were not different between the 2 treatments. Since the study was primarily looking at economic differences between these 2 treatments they only reported YG, but did not report LM area; which would have been useful in further analyzing why YG was not different. Lancaster et al. (2014) also reported that feedlot placement BW was greater for yearlings (367 kg) than calf-feds (251 kg) and that final BW was greater for yearlings (555 kg) than calf-feds (529 kg). However unlike Griffin et al. (2007) that reported greater HCW for long-yearlings, the Lancaster et al. (2014) meta-analysis only observed a tendency for yearlings (345 kg) to have a greater HCW than calf-feds (337 kg). Additionally, there was only a tendency for LM area to be greater for yearlings (81 $cm^2$) than calf-feds (79 $cm^2$). This lack of difference could have been due to some of the studies in this meta-analysis not feeding the cattle to a common $12^{th}$ rib fat endpoint, the rib fat thickness results support this statement because they reported less rib fat for yearlings (1.20 cm) than calf-feds (1.38 cm). As mentioned in a previous section, it is important to feed cattle to a common rib fat endpoint since marbling and fat depth both increase with time on feed (Klopfenstein et al., 1999). Since backgrounding cattle, subsequently shift their mature BW potential up by increasing the accretion of protein mass (Owens et al., 1993), it would be expected that if you fed cattle from these 2 different backgrounding systems (calf-fed vs. yearling) to a common rib fat thickness then calf-feds would also have a greater HCW and LM area at the end of the finishing phase. However marbling score (423) and YG (2.9) was not different between the 2 treatments, despite the differences in rib fat thickness; which is similar to the results reported by Griffin et al. (2007).

Conversely, Sainz et al. (1995) reported that steers consuming either an ad libitum, high-concentrate diet (CA) or limit-fed, high-concentrate diet (CL) during growing had a greater HCW (308 and 303 kg, respectively) than steers consuming a high-forage diet at ad libitum (FA) (296 kg). Although steers were fed to a common final BW (497 kg), rather than a common rib fat thickness. These results however fit the design of the study because they separated out the a growing (57 d) and finishing (96 d) phase for the CA (calf-feds) although they were consuming the 43% rolled wheat and 22% rolled corn diet (i.e. high-concentrate diet) at ad libitum the entire time. They indicated that the feedlot placement BW was greatest for CA steers (303 kg), followed by CL steers (292 kg), and least for FA steers (283 kg). However, if you used the BW comparison at which time the CA steers originally went on the high-concentrate diet, then the CL steers (292 kg) would have had the greatest feedlot placement BW, followed by the FA steers (283 kg), and least for the CA steers (245 kg). As indicated earlier these steers were not fed to a common 12th rib fat thickness; in which CA steers and CL steers had a greater back fat thickness (1.26 and 1.16 cm, respectively) than FA steers (0.99 cm). If FA steers had been fed longer to achieve a similar back fat then it is most likely that they also would have had a greater HCW. Results for the LM area also followed a similar trend with CA and CL steers having the greater LM area (67 and 69 $cm^2$, respectively) than FA steers (60 $cm^2$); which if also fed to a similar back fat thickness the FA steers would have potentially had similar if not greater LM area than the CA and CL steers. Interestingly though there was no difference in marbling score (8.5; with 8 = $Slight^{50}$ and 9 = $Slight^{100}$) or USDA YG (3.3), despite the difference in back fat thickness. This lack of difference in marbling score despite differences in backgrounding system appears to be a common theme for the majority of including Griffin et al. (2007) and Lancaster et al. (2014). It would be interesting to see if the FA steers could obtain a greater marbling score if they had been fed to a common back fat thickness though. Vasconcelos et al. (2009) did not observe these same results although similar treatments were used; 1) steers fed an ad libitum high-forage diet (AF), 2) a limit-fed high-concentrate diet (LC), and 3) an ad libitum high-concentrate diet (AC) during the growing phase (i.e. calf-feds). Just like the Sainz et al. (1995) study they also separated out the a growing (56 d) and finishing (84 d) phase for the AC (calf-feds) although they were consuming the 80% steam-flaked corn (i.e. high-concentrate diet) at ad libitum the entire time. This resulted in the AC steers (417 kg) having a greater feedlot placement BW compared to the AF and LC steers (392 and 372 kg, respectively). However if comparisons were made using the time that AC steers originally went on the high-concentrate diet, then the AF and LC steers would have had a greater feedlot placement BW (392 and 372 kg, respectively) than AC steers (296 kg). All steers were also slaughtered after the 140 d trial; therefore AC had 140 d on the finishing diet and AF and LC were on the finishing diet 84 d. Since steers were not fed to a common rib fat thickness, AC steers had a greater back fat thickness (1.26 cm) than LC and AF steers (0.96 and 0.90 cm, respectively). Due to the experimental design they reported that steers fed the ad libitum high-forage and high-concentrate diets resulted in the greater HCW (351 and 357 kg, respectively), compared to steers limit-fed a high-concentrate diet (326 kg) (Vasconcelos et al., 2009). Surprisingly though LM area was not different among the treatments (89 $cm^2$). However, YG was most favorable for the 2 backgrounding treatments (AF and LC) (2.15) than calf-feds (AC) (2.71). Similarly to the differences in back fat thickness, marbling score was greatest for the AC steers (538), followed by the LC steers (491), and least for the AF steers (453) (Vasconcelos et al., 2009). Just like the statement mentioned earlier about the Sainz et al. (1995) study, the AF steers could have potentially had a similar marbling score if they had been fed to a common back fat thickness.

*Effect of feedlot placement age*

Conclusions from a review by Reuter and Beck (2012) emphasize that feedlot placement age and BW is a primary determinant of a calf's potential value during finishing. The effect of age alone without the confounding effects of placement BW is hard to separate and evaluate. An experimental study should be designed in such a way to have varying ages as treatments with a similar BW at feedlot entry, to truly evaluate the effect of age at feedlot entry. However studies involving calves with varying age also typically have different placement BW due to different backgrounding systems. There was one study conducted by Barham et al. (2012) that came the closest to accomplishing the above mentioned goal of different feedlot placement ages, but similar feedlot placement BW. After a 63 day preconditioning period calf-feds were sent directly to the feedlot to begin the finishing phase, while yearlings from the same preconditioning group were placed on cool-season pasture (Exp. 1) and warm-season pasture (Exp. 2) for 133 d of grazing. The effect of an aggressive versus delayed implant regimen was also evaluated, but there was no interaction of placement age with implant program observed for any of the subsequent finishing performance and carcass characteristic variables of interest. Calves (a mix of heifers and steers) in the calf-fed treatment were placed in the feedlot at 285 d of age and with a 300 kg BW, whereas calves in the yearling treatment were placed in the feedlot at 410 d of age and with a 310 kg BW. Beginning and final BW was taken the morning before feeding without removing the calves from feed and water, and all cattle were fed to a common 12$^{th}$ rib back fat thickness of 1.27 cm as determined visually by an experienced feedlot personnel. However, the goal of feeding to a common rib fat endpoint was only accomplished in Exp. 1 (1.45 cm, average of all treatments); whereas in Exp. 2, calf-feds had a greater rib fat thickness (2.2 cm) than yearlings (1.6 cm). Increased placement age resulted in an increase of 0.36 kg/d for finishing ADG (Exp. 1 and Exp. 2) and an increase in DMI by 3.8 kg/d (Exp. 1) and 1.5 kg/d (Exp. 2). Increased age at feedlot placement also caused a decrease of 32 d on feed during finishing and a decrease of 97 marbling score units in Exp. 1; this resulted in calf-feds having an average choice OG and yearlings having a low choice OG. Conversely, age had no effect on marbling score in Exp. 2 (449), and all treatments were in the low choice QG category. The difference of marbling score in Exp. 1 and no difference in marbling score for Exp. 2 is unexpected since rib fat was the same in Exp. 1 but greater for calf-feds in Exp. 2.

Additionally, a regression analysis was conducted on raw data of calves that went through a forage based growing phase before entering the feedlot and fed a common finishing diet until slaughtered at a common targeted back fat endpoint of 1.2 cm (Barham et al., 2012; Robinette et al., 2011, 2012). Results of the regression analysis indicated that for each day of increased age at feedlot entry, there was a reduction in feeding d required to finish at a common back fat thickness of 1.2 cm (0.3 ± 0.016 d; $R^2 = 0.52$), HCW increased (0.08 ± 0.03 kg; $R^2 = 0.02$), marbling score decreased (0.31 ± 0.082; $R^2 = 0.04$), and WBSF increased (0.004 ± 0.0008 kg; $R^2 = 0.52$). Reuter and Beck (2012) indicated though that most carcasses in these studies were within low choice QG and WBSF values were well below the consumer toughness threshold of 4.3 to 4.5 kg deemed by Miller et al. (2001). Therefore the impact of age on carcass characteristics was minimal.

*Effect of growing phase diet type*

Changes in visceral organ tissue due to different diet types and different intakes in various backgrounding systems can affect ADG differences and also feed efficiency. Williams et al. (1992) reported that changes in protein mass of the empty digestive tract and liver due to altered nutrients can occur within a few wk. Ultimately affecting ADG depending on when BW measurements were taken relative to when cattle were consuming certain diets, or if cattle had recent changes in feed management. Hill et al. (1996) conducted an experiment collecting individual intakes, BW, and carcass data on crossbred steers in 3 different treatments 1) ad libitum 78% corn diet for 130 d, 2) limit fed 78% corn diet for 62 d and then ad libitum 78% corn diet for 68 d, and 3) ad libitum high-forage diet (36% corn) for 62 d and then ad libitum 78% corn diet for 68 d. All body and organ weights were taken separately from 2 steers per treatment when they were slaughtered at the end of the first 62 d growing phase. These results indicated that steers previously consuming the ad libitum forage diet had greater empty rumen (15.8 kg), large intestine (7.4 kg), and total gastrointestinal tract (90.5 kg) weights at the start of the finishing phase. Liver weight was greater for steers consuming the ad libitum concentrate diet and forage diet (7.2 and 7.1 kg, respectively) than limit fed concentrate diet steers (5.2 kg). Therefore it is important to take these factors into consideration when taking weight measurements and reporting ADG differences to alleviate some of the confounding errors due to organ weight variation. Results from this study indicated that growing phase intake differences and diet type differences caused forage fed steers to have the greatest finishing phase DMI (11.8 kg/d), followed by ad libitum concentrate steers (10 kg/d), and least for limit-fed concentrate steers (8.7 kg/d); whereas finishing phase ADG was not affected by treatment. Finishing phase G:F was greater for both limit and ad libitum fed concentrate steers (0.18 kg/kg and 0.17 kg/kg, respectively) than ab libitum fed forage steers (0.15 kg/kg). Calves were fed to a common 12$^{th}$ rib back fat thickness (1.7 cm) which resulted in final HCW being greatest for ab libitum fed forage steers (345 kg), followed by ad libitum concentrate steers (334 kg), and least for limit fed concentrate steers (317 kg). When and they adjusted BW based on HCW and a common DP of slaughtered steers at the start of finishing at the end of finishing, differences in LM area (77 cm$^2$), YG (2.9), or marbling score 374 (300 = Traces$^{00}$; 400 = Slight$^{00}$) was observed.

A meta-analysis by Lancaster et al. (2014) using 13 experiments that evaluated differing levels of starch in growing diets and its effect on subsequent finishing performance and carcass characteristics, concluded that starch content in the backgrounding diet had minimal to no effects on subsequent finishing performance and carcass characteristics. The levels of starch analyzed by the 13 trails used were broken down into high (76% grain and $NE_g$ = 1.42 Mcal/kg of DM), medium (45% grain and $NE_g$ = 1.02 Mcal/kg of DM), and low starch (16% grain and $NE_g$ = 1.03 Mcal/kg of DM). Corn was also the predominant grain fed as a concentrate except one study that fed rolled wheat, and all studies were fed to or adjusted to a common 12$^{th}$ rib fat thickness. When comparing the high and medium starch groups, finishing ADG was the same (1.5 kg/d) for both treatments.

McCurdy et al. (2010) observed mixed results in finishing performance and carcass characteristics when compared to the previous 2 studies. They conducted an experiment analyzing calf-feds (CF), provided ad libitum of a high-concentrate diet versus 3 different backgrounding systems: 1) grazing winter wheat pasture (WP), 2) ad libitum fed a sorghum silage diet (SF), and 3) limit fed the high-concentrate (LC). All backgrounded treatments were in the growing phase for 112 d, then put on the same high-concentrate diet with ad libitum access following the growing phase. All treatments were fed to a common 12$^{th}$ rib fat thickness before slaughter, which was achieved (1.29 cm). They targeted for the 3 backgrounding systems to have similar ADG during the growing phase and simultaneously have similar feedlot placement weights and age following the growing phase. This study design would allow them to only look at the effect of different diet types on subsequent finishing performance and carcass characteristics. Results from the growing phase held true to the design of the study in which ADG was 1.15 kg/d for WP, 1.10 kg/d for SF, and 1.18 kg/d for LC and feedlot placement BW was 382, 369, and 377 kg respectively. Similarly to Hill et al. (1996), they found no difference among the 3 backgrounding treatments regarding finishing DMI (10.5 kg/d), but the CF had the least DMI (8.6 kg/d). However, McCurdy et al. (2010) did report differences in finishing ADG with SF having the greatest (2.02 kg/d), followed by LC (1.85 kg/d), and ADG was least for WP and CF (1.64 and 1.63 kg/d, respectively). Feed efficiency was greater for CF, SF, and LC (0.187 kg/kg) than WP (0.156 kg/kg). McCurdy et al. (2010) indicated that stress due to shipping WP steers from wheat pasture to the feedlot and adapting them to the pen, bunk, and water could have caused the observed decrease in G:F for the WP steers. McCurdy et al. (2010) indicated however that they did observe increased marbling scores for SF and LC (449 and 423, respectively) than WP and CF (409 and 401, respectively) despite no difference in 12$^{th}$ rib fat thickness for the 3 backgrounding treatments (1.29 cm) and a greater rib fat thickness for the CF steers (1.63 cm). This result is different than Hill et al. (1996) and Lancaster et al. (2014), which observed no difference due to backgrounding diet. The SF and LC steers also had greater LM area (89.7 and 89.0 $cm^2$, respectively) and favorable YG (2.76 and 2.94, respectively) than WP and CF steers (LM area = 86.5 and 84.5 $cm^2$, respectively) and (YG = 3.19 and 3.39, respectively). In general the majority of studies indicate that differences in growing phase diet does not impact subsequent carcass characteristics.

*Effect of growing phase ADG*

The effect of growing phase ADG is a key factor in determining stocker system profitability for producers that just background calves (Horn et al., 2005) and it also is thought to impact cattle's ability to express compensatory gain during the finishing phase; which would be a key component in determining profitability for producers that intend to retain ownership after the growing phase or for solely cattle feeders (Reuter and Beck, 2012). A regression analysis using the raw data of Robinette et al. (2011, 2012) and Barham et al. (2012), and reported in the Reuter and Beck (2012) review, included cattle that were finished directly as calves or had been in different forage based growing phases, before consuming the same finishing diet during the finishing phase until a common back fat endpoint was met (1.2 cm). Forage based backgrounding systems consisted of cool-season annual pastures or warm season perennial pasture for a 133 d growing period. Results from this regression equation indicated that ADG during the growing phase was negatively correlated to finishing phase ADG (-0.002 ± 0.0006; $R^2$ = 0.04; $P < 0.01$) and G:F (-0.00009 ± 0.00001; $R^2$ = 0.17; $P < 0.01$). Indicating that for every 1 kg/d increase in growing phase ADG it would be expected that finishing phase ADG would decrease by -0.002 kg/d and G:F would decrease by -0.00009 kg/kg. In regards to carcass characteristics they reported that total BW gain during the growing phase was positively related to HCW (0.27 ± 0.05; $R^2 = 0.11$; $P < 0.01$) and ribeye area (0.007 ± 0.0009; $R^2 = 0.24$; $P < 0.01$). Whereas total BW gain during growing had no effect on either marbling score or Warner Baszler Shear Force, indicating that growing phase ADG had no effect on carcass quality. Reuter and Beck (2012) concluded that increased BW gain during the growing phase is maintained through the finishing phase resulting in increased HCW and LM area, without affecting carcass quality, as long as steers are fed to a common 12$^{th}$ rib fat endpoint.

A similarly designed regression model, was created in a meta-analysis using 29 experiments, which consisted of varying backgrounding systems (grazing different forage types, provided different levels and types of supplementation, or fed high-roughage diets in drylot), and a range of ADG from 0.15 to 1.68 kg/d, with ADG treatment differences ≥ 0.10 kg/d (Lancaster et al., 2014). Calves in every experiment were finished on a common finishing diet. However, different experiments in this analysis fed to different finishing endpoints (i.e. common days on feed during finishing, common final BW, or common rib fat thickness), unlike the Reuter and Beck (2012) regression analysis. Results indicated that growing phase ADG was negatively related with finishing phase ADG (-0.1533 ± 0.0443; $R^2 = 0.301$) and G:F (-0.0173 ± 0.00004; $R^2 = 0.492$). Ultimately concluding that slower gaining backgrounded steers would result in greater ADG and G:F during the finishing phase (Lancaster et al., 2014); which is similar to the conclusions of Reuter and Beck (2012). However, finishing DMI did not have a significant correlation with growing phase ADG alone, but feedlot placement BW alone did have a positive correlation (0.0105 ± 0.0021 * initial finishing BW; $R^2 = 0.216$; ; $P < 0.01$) with finishing phase DMI. Additionally the combination of feedlot placement BW and growing phase ADG had an even stronger relationship with finishing phase DMI (-3.5096 ± 0.4303 * ADG + 0.0257 ±

0.0024 * initial finishing BW; $R^2 = 0.797$; $P < 0.01$). Lancaster et al. (2014) also looked at the impact growing phase ADG had on carcass characteristics. It is important to keep in mind though that experiments included in this analysis did not always feed to a common rib fat thickness, as was previously mentioned. They reported that growing phase ADG was positively correlated with HCW (27.4394 ± 9.8434; $R^2 = 0.788$) and LM area (4.9965 ± 1.5243; $R^2 = 0.419$). However there was no significant correlation of growing phase ADG with YG, fat thickness, or marbling score. Suggesting that rate of growth during the growing phase has minimal impact on marbling score, but marbling score was better correlated with rib fat thickness ($R^2 = 0.69$; Lancaster et al., 2014). Further indicating that for fair comparisons when attempting to compare treatments it is very important to feed cattle to a common rib fat thickness.

Conversely, Hersom et al. (2004) reported that growing ADG ranging from 0.15 to 1.31 kg/d had no effect on finishing performance (ADG, DMI, and G:F). Results from this study were included in the Lancaster et al. (2014) regression analysis. Steers in this study were assigned to 3 treatments 1) high rate of BW gain while grazing wheat pasture (1.2 kg/d) (HGW), 2) low rate of BW gain while grazing wheat pasture (0.61 kg/d) (LGW), 3) grazing dormant native range, and supplemented with 0.91 kg/d cottonseed meal (0.16 kg/d) (NR). All steers in the 2 experiments (yr 1 and y 2) came from a mutual cow herd. In Exp. 1 grazing occurred for 122 d and in Exp. 2 for 144 d. Four steers from each treatment were also slaughtered after the growing phase to evaluate body composition, so differences in gut fill were able to be accounted for. Feedlot placement BW was different for the 3 treatments in both Exp. 1 and Exp. 2, as HGW steers had the greatest initial feedlot BW (404 and 395 kg, respectively), followed by LGW steers (311 and 333 kg, respectively), and least for NR steers (255 and 257 kg, respectively). The remainder of steers were placed in the feedlot and transitioned over 4 wk to a common high-concentrate, finishing diet (81.5% corn) until a common rib fat endpoint (1.27 cm) was reached. The HGW, LGW, and NR steers were on the finishing diet for different d (89, 116, and 163 d, respectively). Combined results from the 2 experiments indicated that there was only a tendency for finishing ADG to be greater for NR steers (1.81 kg/d) than HGW and LGW steers (1.71 and 1.68 kg/d, respectively). This minor tendency for NR steers to have greater finishing phase ADG, combined with the longer days on feed resulted in final live BW to be greater for HGW and NR steers than LGW steers in both experiments. There was no effect of growing ADG on finishing phase DMI (10.2 kg) or G:F (0.173 kg/kg). It is difficult to explain why this study observed no difference in subsequent finishing performance, while the majority of other studies do. It could potentially be due to all 3 treatments being evaluated were consuming a primarily fibrous diet, while in other studies it is comparing experiments in which some treatments are consuming a forage diet, whereas other consume a limit fed or ad libitum concentrate diet. This could cause major changes in rumen fill if the other studies did not account for that difference appropriately. This study on the other hand reported ADG and G:F on both a live BW and empty BW basis and observed no difference.

**Conclusions and Experiment Objectives**

The variety of opportunities to background fall weaned calves abound. Especially in Nebraska, where corn residue hectares are abundant and there is potential to graze a fall planted double crop forage after silage or cash crop harvest. However it is important to keep in mind the entire system when considering these options. Maintaining soil health and structure, minimizing detriment to subsequent cash crop grain yields, and optimizing animal performance to fit the needs of the producer are key goals to make this integrated crop-livestock system as sustainable and profitable as possible. Crop and cattle producers will have to work together and create reasonable expectations that both individuals can adhere to, for the best utilization of available resources. Nebraska additionally has an advantage with an ample supply of corn byproducts such as distillers grains from many ethanol plants across Nebraska and in the surrounding states. This coproduct can be used as an excellent source of RUP to growing calves while grazing corn residue. Based on the preceding literature, research evaluating perceptions of crop consultants and producers on grazing corn residue, forage yield and quality of fall planted oat-brassica mixes, and subsequent finishing performance and carcass characteristics of growing calves backgrounded on these forages (corn residue or oat-brassica forage) over the winter were conducted in the following experiments.

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# CHAPTER II. Perceptions of Crop Consultants and Producers on Grazing Corn Residue in Nebraska†

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**ABSTRACT**

We conducted a survey to evaluate factors influencing consultant recommendations on grazing and producer grazing practices in Nebraska. Producers who did not graze cited soil compaction, inconvenience (watering and fencing), and lack of access to livestock as major factors. Producers who allowed grazing and consultants who recommended grazing were more likely to perceive that grazing increased subsequent grain yields than those who did not. Most consultants and producers reported making decisions based on their personal observation. Findings from the survey can thus be used for enhanced Extension dissemination and research activities regarding grazing of residues.

**Key Words:** agriculture survey, beef cattle, crop yield, grazing corn residue, soil properties

## INTRODUCTION

Grazing corn residue has been practiced for many years and was researched as early as the 1970s. Vetter, Weber, and Gay (1970) studied the effects of grazing cornstalks on beef cow performance, and Ward (1972) analyzed the feeding value of crop residues. Additionally, the effects of grazing corn residue on subsequent crop yields (Clark et al., 2004; Drewnoski, MacDonald, Erickson, Hanford, & Klopfenstein, 2016) and soil properties (Clark et al., 2004; Tracy & Zhang, 2008) have also been researched. Grazing of corn residue can lower winter feed cost for cattle producers by extending the grazing season as opposed to feeding harvested and stored forages (Rasby, Drewnoski, & Stalker, 2014).

However, Stalker et al. (2012) stated that only 25% of corn residue acres in Nebraska are currently grazed. Much of the cropland, and thus corn residue, is under the control of producers who specialize in crop production and do not have cattle themselves. Renting corn residue for grazing to cattle producers can be a source of extra income for such crop producers. However, the perceptions of crop consultants who provide advice to crop producers and the perceptions of crop producers themselves regarding grazing of corn residue have not been studied. Therefore, we conducted a survey to better understand the perceptions and factors influencing behaviors of crop consultants and crop producers regarding grazing corn residue. The results led us to conclusions about opportunities for targeted Extension programming.

## METHODS

### *Survey methodology and measures*

Consultants were asked to fill out a 16-question survey, and producers were given a 14-question survey. Some questions were similar across surveys to allow comparison of responses between consultants and producers. We estimated that it would take 15 to 25 min to complete a survey. We used an online survey software (Qualtrics, Provo, UT, V. 2015) for creating the survey instruments and storing data. An electronic mailing list developed by University of Nebraska Extension educators was used for distributing the surveys. A cover letter emailed to the participants explained the purpose of the survey and provided instructions for survey completion. A web address link directed participants to the survey. Three emails (initial announcement, mid-point reminder, and final reminder) were sent. The survey was open from January 15 to February 15 of 2015. We did not incentivize the participants for completing surveys. The institutional review board at the University of Nebraska-Lincoln approved the study.

### *Statistical analysis*

We analyzed the data using the Statistical Package for the Social Sciences (SPSS; IBM Corp; Armonk, NY, v. 19) software. We computed and compared means, standard deviations, frequencies, and percent responses. According to the Shapiro-Wilk test of normality, the data did not follow a normal distribution; therefore, we were required to use non-parametric tests for the comparisons and correlations. For all analyses the level of significance was set at $p < .05$.

## RESULTS

### *Background information on respondent groups*

The return rate was 24.9% ($n = 234/940$) for the consultant survey. Seventy-six percent of consultants influenced 4,000 plus ac. (Figure 2.1). Consultant responses indicated that the majority of influenced acres were irrigated (3.5 ± 1.3) and the majority of their clients used a no-till (3.3 ± 1.3) management system (responses were provided through the use of a scale ranging from 1 to 5 that had increasing 20%-unit increments [1 = *0% to 20%* and 5 = *81% to 100%*]).

The producer survey had a return rate of 23.9% ($n = 130/545$). The majority of producers farmed between 200 and 3,999 ac. (Figure 2.1). The land managed by producers was predominantly managed under no-till system (4.4 ± 1.2) and was equally split between irrigated (3.3 ± 1.6) and rain-fed (3.2 ± 1.7) conditions (responses were provided through the use of a scale ranging from 1 to 5 that had increasing 20%-unit increments [1 = *0% to 20%* and 5 = *81% to 100%*]).

*Consultant grazing recommendations and producer grazing practices*

The majority (82%) of consultants in our survey recommended grazing of corn residue to their clients (Figure 2.2). Of the producers surveyed, 63% indicated that their corn residue was used for grazing (Figure 2.2).

*Land management influences*

The proportion of rain-fed acres managed differed ($p < .05$) for producers who allowed grazing as compared to those who did not allow grazing. Producers who allowed grazing reported significantly less rain-fed acres (2.9 ± 1.8) contributing to their total cropland compared to those who did not allow grazing (3.7 ± 1.6) (responses were provided through the use of a scale ranging from 1 to 5 that had increasing 20%-unit increments [1 = *0% to 20%* and 5 = *81% to 100%*]). Due to greater cow numbers in western Nebraska, we estimate that more corn residue acres are grazed in western Nebraska than in eastern Nebraska. Annual precipitation amount gradually decreases from east (34 in.) to west (16 in.) in Nebraska. As a result, irrigated corn acres are greater and rain-fed corn acres are fewer in western Nebraska than in eastern Nebraska. Thus location within Nebraska may explain why producers with fewer rain-fed acres were also more likely to allow grazing.

Regarding survey questions on tillage and planting practices (Table 2.1), 34% of consultants indicated that “some to all” of their clients changed tillage and planting practices after grazing, and 64% indicated that “very few” changed tillage or planting practices. However, 93% of producers who allowed grazing responded that they did not change tillage or planting practices as a result of allowing cattle to graze corn residue.

*Perceptions of grazing effects on land productivity*

The majority of consultants recommended grazing; thus, a statistical analysis comparing those who recommended and those who did not recommend grazing could not be conducted. However, the majority of both consultants recommending grazing and producers allowing grazing perceived the effect of grazing on subsequent grain yields to be neutral or positive (Table 2.2). Producers who did not allow grazing were more likely ($p > .02$) to perceive negative effects of grazing corn residue on subsequent corn (Figure 2.3) and soybean (Figure 2.4) yields relative to producers who allowed grazing. Using a scale ranging from 1 (*greatest decrease*) to 7 (*greatest increase*), producers who did not allow grazing rated the effect on corn yield at 3.79 ± 1.5 and the effect on soybean yield at 3.86 ± 1.8, whereas producers who did graze corn residue ranked the effect on corn yield at 4.86 ± 1.2 and the effect on soybean yield at 4.54 ± 1.3.

*Corn residue rental rates*

The majority (82%) of the producers who rented out corn residue for grazing charged $15 or less per acre (Table 2.3). Interestingly, a large proportion (42%) of producers who did not allow corn residue grazing indicated they would allow cattle to graze their corn residue for a rental fee of $15 or less per acre. However, an equally large proportion (40%) of producers who did not allow grazing of corn residue responded they would not allow grazing regardless of the rental fee offered.

*Reasons for not grazing corn residue*

When consultants who did not recommend grazing where asked to rate the importance of reasons why (using a scale of 1 = *very important* to 5 = *not at all important*), the three reasons receiving the highest ratings were as follows:

1. grazing has a negative effect on farming practices (2.03 ± 1.0),
2. grazing reduces subsequent crop yields (2.31 ± 1.2), and
3. livestock producers would not pay for the worth of corn residue (2.38 ± 1.3).

When producers who did not allow grazing where asked to identify their reasons why by indicating all applicable answer choices for a “select all that apply” question, the top three reasons were as follows:

1. soil compaction (47%),
2. inconvenience (lack of water and fencing) (49%), and
3. other - lack of access to livestock (23%).

However, when we compared responses of producers who did not allow grazing but indicated that they would for a fee and producers who indicated that they would not allow grazing regardless of fee offered, we found differences in their reasons for not grazing (Table 2.4).

The majority of producers who would not allow grazing regardless of rental fee offered indicated that they felt grazing caused compaction (65%) or had a negative effect on their tillage or planting operation (55%). However, 60% of the producers who would allow grazing for a rental fee selected “other,” and according to their comments, approximately 70% of those respondents indicated that they did not have access to livestock for grazing. Thus, lack of access to livestock was the highest ranked reason (42%) for not grazing among producers who were not grazing but indicated they would allow grazing for a fee.

*Source of information regarding grazing corn residue*

We found that personal observation is often used by producers and consultants as a source of information (Figure 2.5).

*Limitations of the survey*

Limitations of our survey, including question design, distribution, response population, and analysis, should be considered. Survey analysis would have been simpler, had there been fewer "select all that apply" questions. Responses to these questions summed to greater than 100%, making analysis and interpretation more challenging and limiting the ability to conduct statistical comparisons.

There also could have been population bias. All consultants and producers who were surveyed likely collaborate with the University of Nebraska Extension service providers because the mailing list used was collected from Extension educators. Another bias that can be difficult to control and account for is non-response bias. An increased variety of survey delivery formats and reminders could have increased the response rate. Incentives also could have encouraged increased participation by consultants and producers. However, the return rates of both the consultant survey (25%) and the producer survey (24%) are similar to those for other recent agriculture related surveys, such as 21% (Dahlen, Hadrich, & Lardy, 2014) and 22% (Boyd et al., 2015).

## IMPLICATIONS

The majority of crop consultants and crop producers did not perceive that grazing corn residue negatively affects subsequent crop yields. Instead, crop producers' reasons for not allowing grazing were related to concerns about soil compaction, lack of access to livestock, and perceptions of negative effects on farming practices.

On the basis of these responses, we believe there is an opportunity to increase the number of corn residue acres grazed in the Midwest through targeted Extension programming.

- A program connecting cattle producers looking for corn residue and farmers interested in renting out their corn residue for grazing would be beneficial as many crop producers in our survey indicated an interest in renting out grazing for a fee that is within the range of current rental rates.
- More education is needed related to the effect of grazing corn residue on soil compaction. Research pertaining to the effects of grazing corn residue on compaction does not support the concerns indicated by producers in our survey. In a long-term study (16 years), Rakkar et al. (2016) concluded that fall grazing at the recommended stocking rate had no effect on soil compaction. This disconnection between research results and producer perceptions highlights the need for increased dissemination of research results.
- There is an opportunity for “peer to peer” learning regarding the need for changes to tillage and planting practices due to grazing. The overwhelming majority of producers who currently graze corn residue indicated that they did not change tillage or planting practices due to grazing. Likewise the majority of crop consultants indicated that very few of their clients had to change practices due to grazing.

Lastly, when producers and consultants were asked about sources of information they used to make decisions regarding corn residue, “personal observation” was ranked the highest by both groups. We believe that the reliance on “observations” indicates a need to help both producers and consultants understand that without a proper control treatment the individual has no way to truly compare effects of management practices and thus may be misled. Education on the value of using information based on scientific methods will help producers and consultants make sound management decisions.

## ACKNOWLEDGMENTS

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**Table 2.1. Perceptions of Consultants and Producers Regarding Land Management Changes When Corn Residue is Grazed**

| Change to tillage or planting practices | % of Responses |
|---|---|
| Consultants | |
| Some to all of my clients have changed | 34 |
| Very few of my clients have changed | 64 |
| My clients do not allow grazing | 2 |
| Producers that allowed grazing | |
| Yes, I changed | 7 |
| No, I did not change | 93 |

**Table 2.2. Consultants Recommending and Producers Allowing Grazing: Perceptions of the Effect of Grazing Corn Residue on Subsequent Crop Yield**

| | Consultants recommending grazing (*n* = 185)[a] | | Producers allowing grazing (*n* = 92)[b] | |
|---|---|---|---|---|
| **Crop yield** | ***n*** | **%** | ***n*** | **%** |
| Corn | | | | |
| Decrease | 38 | 20.6 | 17 | 18.5 |
| No effect | 75 | 40.8 | 46 | 50.0 |
| Increase | 71 | 38.6 | 29 | 31.5 |
| Soybean | | | | |
| Decrease | 28 | 15.1 | 17 | 19.1 |
| No effect | 89 | 48.1 | 43 | 48.3 |
| Increase | 68 | 36.8 | 29 | 32.6 |

[a]One consultant recommending grazing did not respond to the question regarding corn yield.
[b]Three producers allowing grazing did not respond to the question regarding soybean yield.

**Table 2.3. Rental Rates Charged by Producers Currently Renting Out Corn Residue and Rates Desired by Producers Currently Not Allowing Grazing**

| | Currently rent[a] ($n$ = 26) | | Currently do not allow[b] ($n$ = 50) | |
|---|---|---|---|---|
| **Grazing fee** | ***n*** | **%** | ***n*** | **%** |
| Free | 6 | 23.5 | 7 | 14.0 |
| $1 to $15 per ac. | 15 | 58.8 | 14 | 28.0 |
| $16 to $25 per ac. | 5 | 17.7 | 4 | 8.0 |
| $26 to $35 per ac. | 0 | 0.0 | 2 | 4.0 |
| > $35 per ac. | 0 | 0.0 | 3 | 6.0 |
| Would not allow grazing regardless of rental fee | | | 20 | 40.0 |

[a]What rental fee do you charge?
[b]What rental fee would you need before you would allow cattle to graze?

**Table 2.4. Reasons for Not Grazing: Comparing Producers Who Do Not Graze but Would for a Fee and Those Who Would Not Graze Regardless of Fee**

| **Reason corn residue is not grazed**[a] | **Would rent for a fee (*n* = 30), %** | **Would not graze regardless of rental fee (*n* = 20), %** |
|---|---|---|
| Reduces subsequent crop yields | 0.0 | 10.0 |
| Negative effect on farming practices | 10.0 | 55.0 |
| Lack of water for livestock | 26.7 | 40.0 |
| Lack of fencing | 10.0 | 30.0 |
| Livestock producers will not pay for worth of stalks | 30.0 | 25.0 |
| Interferes with fall field work | 23.3 | 25.0 |
| Causes soil compaction | 20.0 | 65.0 |
| Other | 60.0 | 30.0 |

[a]Survey item was a “select all that apply” question; therefore, percentages sum to greater than 100%.

**Figure 2.1. Number of Acres Influenced by Consultants and Directly Farmed by Producers**

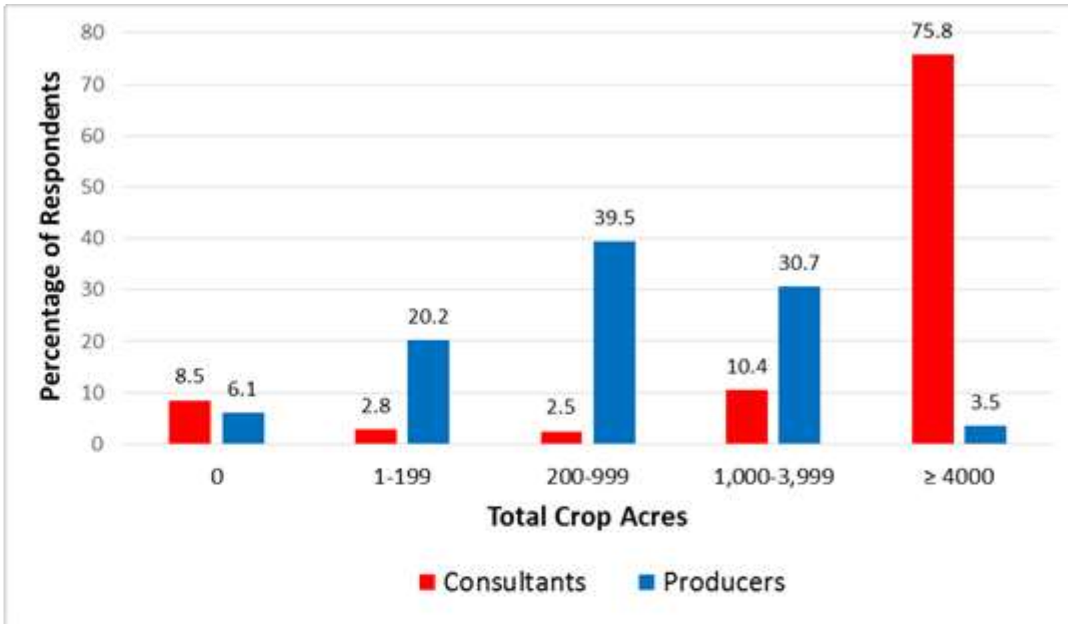


**Figure 2.2. Consultant Grazing Recommendations and Producer Grazing Practices**

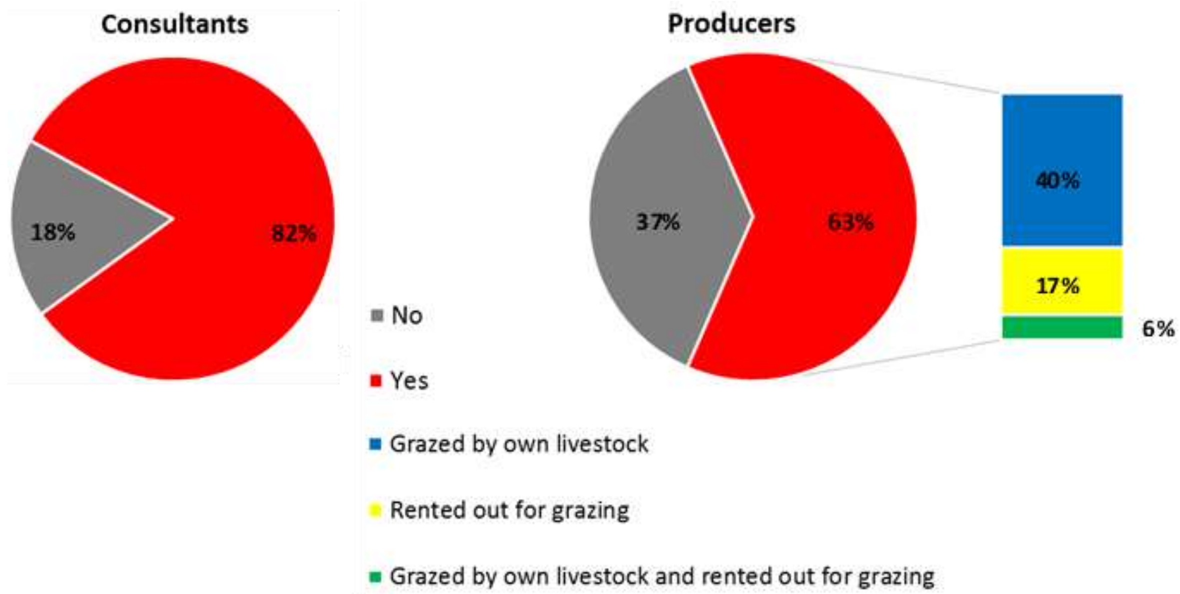


**Figure 2.3. Producers Allowing Versus Not Allowing Grazing: Perceptions of the Effect of Grazing Corn Residue on Subsequent Corn Yield**

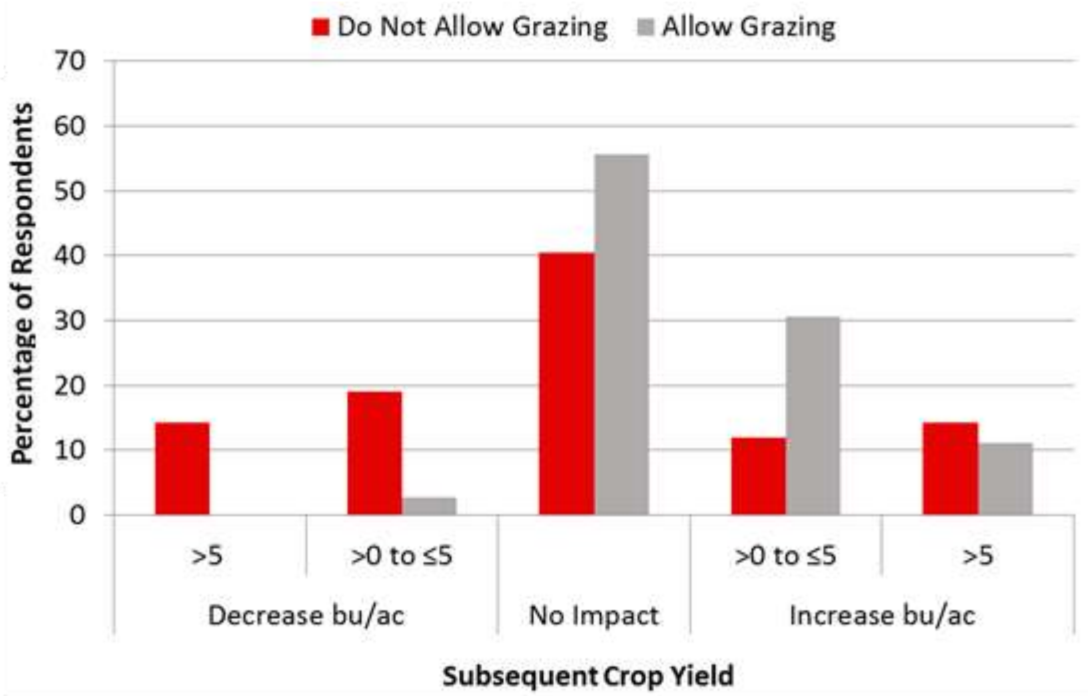


**Figure 2.4. Producers Allowing Versus Not Allowing Grazing: Perceptions of the Effect of Grazing Corn Residue on Subsequent Soybean Yield**

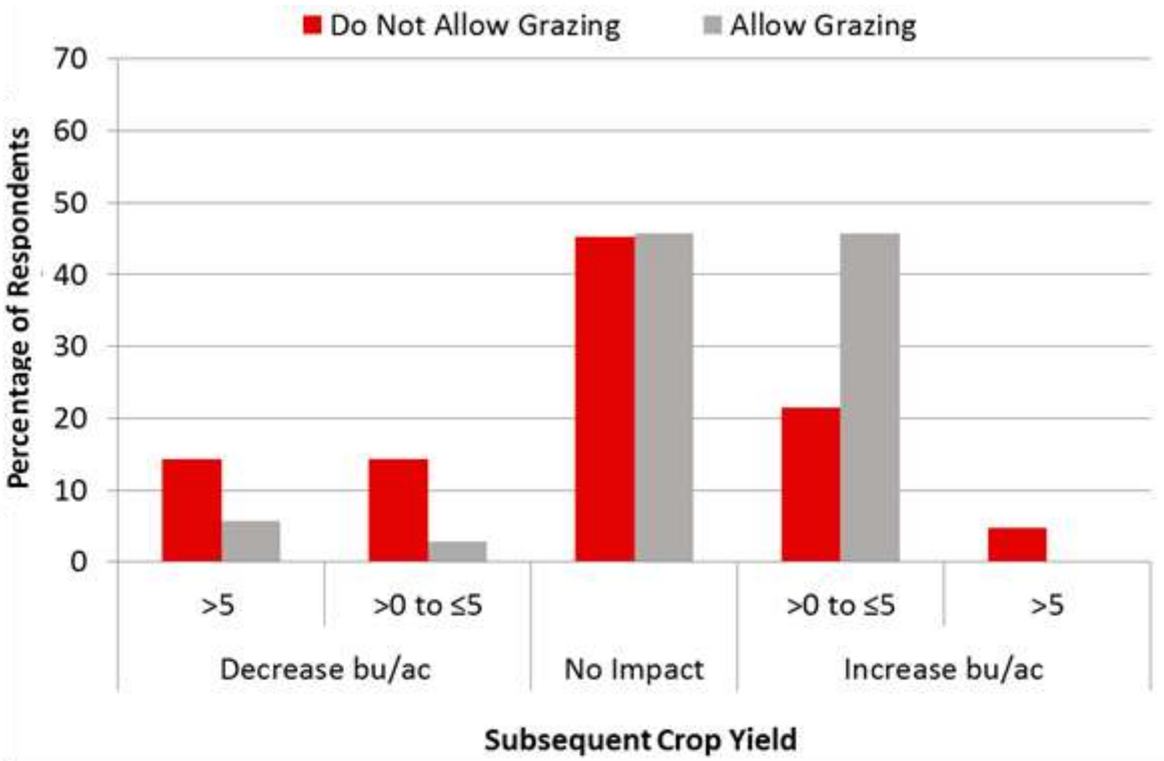
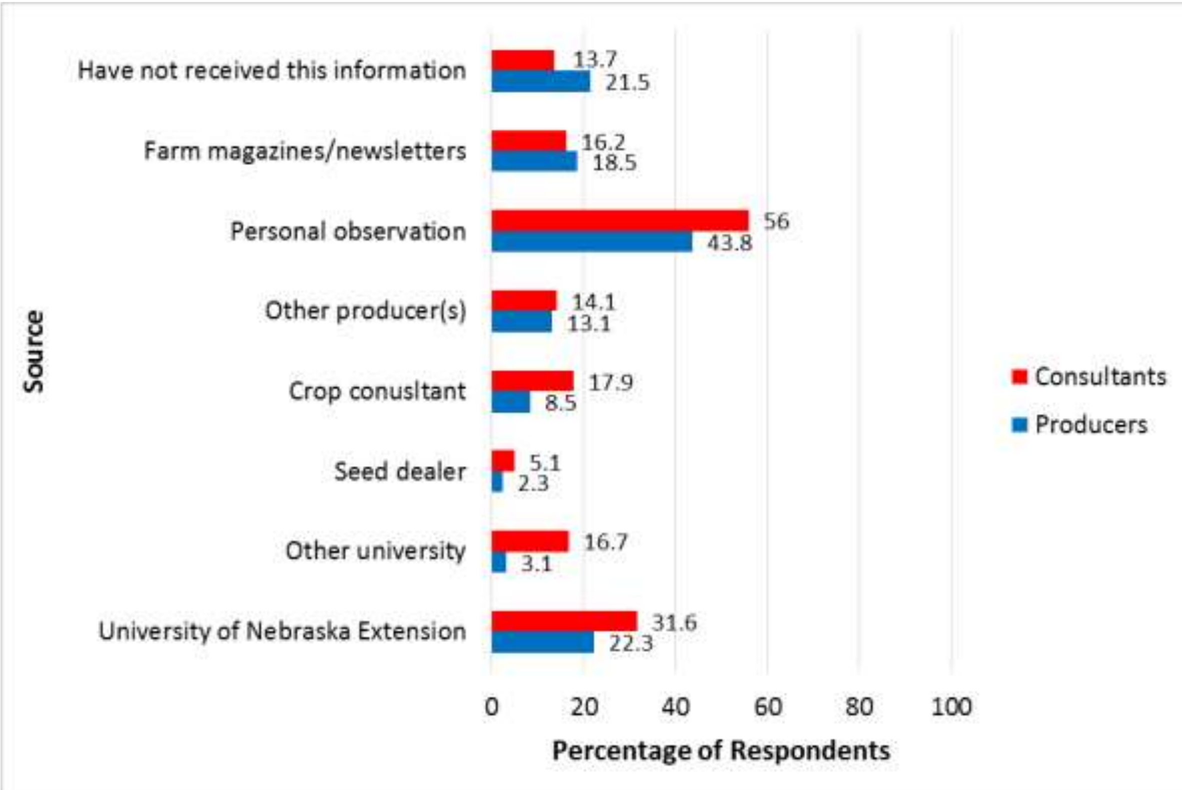


**Figure 2.5. Survey Respondents Sources of Information**



# CHAPTER III. The effects of backgrounding system on growing and finishing performance, and carcass characteristics of beef steers†

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**ABSTRACT**

The abundance of diverse forage resources in the Midwest, provides cattle producers many different options to background calves prior to placing them in a feedlot and finishing them out for meat harvest. This 2-yr study evaluated growing and finishing performance, as well as carcass characteristics of spring-born steers backgrounded using 1 of 3 different systems using feedstuffs readily available in the Midwest: 1) grazing corn residue and supplementing 2.68 kg DM/steer of dried distillers grains 6 d/wk (CRD), 2) grazing a late summer planted oat-brassica forage mix (OBF), or 3) fed a corn silage-based diet in a drylot (DCS). Steers ($n$ = 715) were stratified by BW (278 kg ± 23 yr 1 and 291 kg ± 91 yr 2) and assigned to treatment and replicate (4 replications per treatment per yr). Oat-brassica forage consisted of 57% oat, 27% turnip (leaf and root) and 16% radish (leaf and root; DM basis). The corn silage-based backgrounding diet contained 51% corn silage, 25% alfalfa hay, 20% wet distillers grains with solubles (WDGS), and 4% supplement (DM basis). During backgrounding, the ADG of DCS (1.48 kg/d) was greater ($P < 0.01$) than both OBF (1.05 kg/d) and CRD (0.87 kg/d), and ADG of OBF was greater ($P < 0.01$) than CRD. At the start of finishing, BW of OBF (381 kg) was greater ($P < 0.01$) than DCS (361 kg) and CRD (366 kg). The finishing diet was fed for 160 d across all treatments and consisted of 55.8% dry-rolled corn, 32.3% WDGS, 8.7% corn silage, and 3.2% supplement. Both 12th rib fat ($P = 0.89$) and calculated YG ($P = 0.39$) did not differ among treatments. Finishing G:F was greater ($P < 0.01$) for DCS in yr 1 (0.167 kg/kg) and yr 2 (0.156 kg/kg) than OBF in yr 1 (0.156 kg/kg) and yr 2 (0.149 kg/kg), and greater ($P < 0.01$) than CRD in yr 1 (0.155 kg/kg), but not different ($P = 0.13$) in yr 2 (0.151 kg/kg). Finishing G:F did not differ between OBF and CRD across yr ($P \geq 0.48$). At harvest, HCW of OBF (401 kg) was greatest ($P < 0.01$), CRD (393 kg) was less than OBF but greater than DCS (391 kg) ($P < 0.01$).

Marbling was greater ($P = 0.01$) for DCS (429) than CRD (414), though OBF (424) was not different ($P \geq 0.10$) from DCS or CRD. The lower cost of gain associated with the grazing systems may make these backgrounding methods economically competitive.

**Key Words:** backgrounding steers, brassicas, carcass quality, corn residue, feedlot

## INTRODUCTION

In the Midwest, there is significant opportunity to background fall weaned calves in the winter using forages produced from crop ha. Corn residue is an abundant forage resource that, with supplementation of protein and energy can be used to background calves (Watson et al., 2015; Tibbitts et al., 2016). Corn silage is often grown near feedlots that intend to use the corn silage as a forage source in receiving and finishing diets. When corn silage is harvested in late-summer, cool-season grasses and brassicas can be planted after to provide fall/winter grazing. The digestibility of late summer planted oats and brassicas is very high (Villalobos and Brummer, 2015; Coblentz and Cavadini, 2016). Unfortunately, there is little published reports regarding the gains when grazing this forage resource and the subsequent finishing performance and carcass characteristics.

Different components of backgrounding management, such as diet type and growing phase ADG have been found to impact subsequent finishing performance and carcass characteristics (Owens et al., 1995; McCurdy et al., 2010; Lancaster et al., 2014). Increased growing phase ADG has been associated with decreased finishing phase ADG (Lancaster et al., 2014) and finishing phase G:F (Reuter and Beck, 2012; Lancaster et al., 2014). Reuter and Beck (2012) and Lancaster et al. (2014) also indicated that increased growing phase ADG results in increased HCW and LM area. However, backgrounding systems appear to have minimal effects, if any, on carcass quality if cattle are finished to equal 12$^{th}$ rib fat (Hill et al., 1996; Reuter and Beck, 2012; Lancaster et al., 2014).

Our objectives were to evaluate the growing and subsequent finishing performance, and carcass characteristics of backgrounded spring-born steers: 1) grazing corn residue and being supplemented with dried distillers grains plus solubles (DDGS), 2) grazing an oats, turnip, radish mix planted after corn silage harvest, or 3) being fed a corn silage-based diet.

## MATERIAL AND METHODS

All animal use protocols were approved by the U.S. Meat Animal Research Center (USMARC) Animal Care and Use Committee.

### *Cattle*

A 2 yr study was conducted at USMARC near Clay Center, Nebraska, utilizing 715 (355 yr 1 and 360 yr 2) spring born, MARC II composite (one-fourth each Gelbvieh, Simmental, Hereford, and Angus) steer calves in yr 1 and a combination of MARC II and purebred angus steer calves in yr 2. Steers were weaned in September and were fed a corn silage-based diet (Table 3.1) before being individually weighed in Mid-November to determine initial experimental BW. Throughout the experiment body weights were taken in the morning prior to feeding. Before each use, the scale was validated using 20 certified weights (22.68 kg each), and calibrated when the actual reading was >0.3% above or below the certified weight.

Steers were stratified by genetic line and BW (278 kg ± 1.2 yr 1 and 291 kg ± 4.8 yr 2) and assigned to 1 of 3 treatments: 1) corn residue grazing with DDGS supplementation (CRD), 2) oat-brassica forage grazing (OBF) or 3) being fed a corn silage-based diet in the drylot (DCS) in a completely randomized design. Each treatment was replicated 4 times per yr and contained 25 to 30 steers per replication.

### *Diets and animal care*

Steers assigned to the DCS treatment were placed in 4 soil-surfaced feedlot pens with 30 steers per pen in both years. Pens were approximately 15.4 by 61 m with a concreate apron extending 4.7 m from the bunk and 15.1 m of bunk space available. Steers assigned to DCS were backgrounded on a corn silage-based diet (Table 3.1) for 54 days in the first yr and 52 days in the second yr, to meet a targeted BW of 363 kg at the end of the growing period (Figure 3.1). At which point they were weighed, implanted with Revalor-XS (200 mg trenbolone acetate and 40 mg estradiol 17β; Merck Animal Health, DeSoto, KS), and transitioned to the finishing diet (Table 3.1) over a 21 to 28 d period.

Steers assigned to OBF were placed in an irrigated field that was seeded with 94 kg/ha of oat, 2.2 kg/ha of daikon radish, and 1.7 kg/ha of purple top turnips after corn silage harvest. Nitrogen was split applied via the pivot with 54 kg of N/ha total (yr 1) and 45.7 kg of N/ha total (yr 2). Initial forage yield before turning steers out to graze was 3756 kg/ha and 5144 kg/ha (DM basis), in yr 1 and yr 2, respectively. Steers were stocked at a rate 1538 ± 37 kg DM/steer (yr 1) and 1984 ± 108 kg DM/steer (yr 2). Initial forage quality of the double crop forage treatment available for grazing is presented in (Table 3.2). On a DM basis the available forage was 57% oats, 22% turnip top, 5% turnip root, 13% radish top, and 3% radish roots. In yr 1, the field was divided into 12.5 ha quarters and the number of steers per quarter varied according to the amount of forage available resulting in 25, 30, 30, and 30 steers per quarter. In yr 2, the field was divided into 14.2, 13.8, 14.6, and 10.2 ha quarters based on the forage yield and stocked with steers 30 steers per quarter. Steers were removed from grazing (65 d yr 1 and 66 d yr 2) when the OBF biomass appeared limiting (1445 ± 104 kg DM/ha in yr 1 and 1401 ± 499 kg DM/ha in yr 2).

Steers assigned to CRD were placed in a harvested irrigated corn field that was divided into 4 quarters with 12.5 ha per quarter in yr 1 and 9.4 ha per quarter in yr 2. In both years each quarter was stocked with 30 steers and steers were supplemented 6 d a wk with 2.68 kg DM/steer of DDGS with limestone added at 2% on a DM basis.  The grazing period lasted 65 d yr 1 and 66 d yr 2. Although corn residue ha were decreased in yr 2 because of a simultaneous experiment sufficient forage would have been available throughout the grazing period in both years. The corn grain yield from these fields averaged 14 t/ha in yr 1 and 13 t/ha in yr 2. Harvest index [dry grain weight / (dry grain weight + dry residue weight)] can range from 0.45 (low yielding situations; ~ 6 t grain/ha) to 0.62 (high yielding situations; ~16 t grain/ha). Assuming a harvest index of 0.58 and a corn residue intake of 3.92 kg DM/steer/d (Gustad et al. 2006) the steers would have consumed 6.1% and 8.7% of the total corn residue available in year 1 and 2 respectively. Assuming that 39% of the corn residue is leaf and husk (Watson et al. 2015) then the steers would have consumed only 16% of the leaf and husk available in yr 1 and 22% in yr 2.

Both CRD and OBF steers were given access to a free choice mineral containing 1,323 g monensin per metric ton (Vigortone Ag Products, Brookville, OH) during the grazing period. At the end of the grazing period each group of steers from both OBF and CRD was placed into a separate soil-surfaced feedlot pens (8 pens/4 reps per treatment) and steers were fed the same corn silage-based ration that DCS had previously received (Table 3.1). After 6 d in yr 1 and 5 d in yr 2, BW were collected for the CRD and OBF steers (Figure 3.1). These BW were taken to correct final grazing BW and ADG for potential differences in gut fill. The gain of the steers during the 5 or 6 d period was calculated using the gains of the DCS steers and was subtracted to calculate the ADG during the grazing period. Steers continued to be fed the corn silage-based ration for an additional 15 d in yr 1 and 28 d in yr 2 (Figure 3.1), in an effort to allow steers to reach a targeted BW of approximately 363 kg. Then they were implanted with Revalor-XS (200 mg trenbolone acetate and 40 mg estradiol 17β; Merck Animal Health, DeSoto, KS), and transitioned to the finishing diet (Table 3.1) over a 21 to 28 d period.

All steers were fed the finishing diet for 160 d in both years. Feed bunks were visually evaluated each day of the experiment at approximately 0630 h to determine the quantity of feed to offer each pen. Bunk management readings were conducted so that less than 0.15 kg of feed per steer remained in the bunk at the time of evaluation. Steers were fed once daily at approximately 0730 h. Wet distillers grains plus solubles (WDGS) used in the experiment was delivered weekly from a single source and stored on a concrete pad. Changes in DM of WDGS were monitored by collecting and drying samples weekly, as well as every time a new load was delivered and after rain events.

On the day of harvest, HCW and harvest order were recorded. After a 24-h chill, LM area, 12$^{th}$ rib fat thickness, and marbling score were determined by USMARC personnel using the VBG2000 beef grading camera (Shackelford et al., 2003). Yield grade was calculated [2.5 + (6.35 X 12$^{th}$ rib fat) + (0.2 X 2.5[KPH]) + (0.0017 X HCW) – (2.06 X LM area)] for each individual steer and then averaged within pen (USDA, 1997). The common dressing percent of steers in the present study of 62% was multiplied by HCW to calculate carcass adjusted final BW; which was used to calculate carcass adjusted ADG and G:F.

*Lab analysis*

Diet samples were collected from the bunks daily (200 g, as-fed basis, from each treatment) and composited by diet type within week and stored at −20°C. Multiple (2 to 3) hand grab samples were collected from each bunk. After the experiment, the weekly samples were thawed and composited to form monthly samples. Composited monthly samples were analyzed for DM, CP, ADF, NDF, ether extract, and starch at a commercial laboratory (Dairyland Laboratories, Inc.; Arcadia, WI). Dry matter intake was calculated by multiplying the as-fed feed delivered by the weekly dry matter percentage of each treatment group.

Biomass and quality samples were collected from the OBF treatment prior to the start of grazing. For biomass determination, 4 random 0.37m$^2$ areas were sampled in each replicate. The turnips and radishes within this area were pulled up so that grazeable root biomass could be included and oats were clipped at ground level. The samples were separated by species with the brassica leaves being separated from the root. The samples were dried in paper bags, in a 60°C forced-air oven (Model LBB2-21-1, Despatch, Minneapolis, MN) until a constant weight was obtained (AOAC, 1965, Method 935.29). Forage quality samples were taken on the same date as the biomass samples. Each species (oats, radish, and turnip) were collected at random within each replicate and put into separate bags according to species type. They were kept in a portable cooler with ice for transport to the laboratory. Once at the lab brassicas were separated into leaf and root and samples were stored frozen. Samples were then freeze-dried (Virtis Freezemobile 25ES, Life Scientific Inc., St. Louis, MO) and ground through a 1-mm screen using a Wiley mill (Thomas Scientific, Swedesboro, NJ). Freeze-dried samples were analyzed for corrected DM (100°C), OM, CP, ADF, and in vitro OM disappearance (IVOMD).

Organic matter was determined by placing samples in a muffle furnace for 6-h at 600°C (AOAC International, 1999: method 4.1.10). Crude protein analyses were determined by using a combustion chamber (TruSpec N Determinatr, Leco Corpoation, St. Joseph, MO; AOAC International, 1999; method 990.03). Acid detergent fiber analysis was conducted according to the Van Soest et al. (1991) method, using an Ankom 200 fiber analyzer (Method 6, ANKOM Technology Corp., Macedon, NY). In vitro OM disappearance analyses was determined after a 48 h incubation period using the method described by Tilley and Terry (1963), modified by adding urea to the McDougall’s buffer (McDougall, 1948) at a rate of 1 g urea/L buffer solution, to ensure adequate RDP was available for microbes in the rumen fluid (Weiss, 1994). Samples from yr 1 were analyzed separately from yr 2. Blanks were included in both incubation runs to adjust for any feed particles that might have come from the inoculum.

*Statistical analysis*

Growth performance data (BW, ADG, DMI, and G:F) and carcass characteristics (HCW, LM area, 12th rib fat, marbling score, and USDA yield grade) were analyzed using the MIXED procedure of SAS 9.3 (SAS Inst. Inc., Cary, NC) with replicate (pen or grazing paddock) as the experimental unit. The model included the fixed effects of backgrounding treatment, yr, and interaction between yr and backgrounding treatment. For all analysis, effects were considered significant at $P$-value ≤ 0.05, with tendencies declared at $P$-values between 0.05 and 0.10. Forage yield was analyzed using the MIXED procedure of SAS 9.3 with replicate as the experimental unit. The model included the fixed effect of species and date, the 2-way interaction of species × date and species × yr, and the 3-way interaction of species, date, and yr. For all analysis, effects were considered significant at $P$-value ≤ 0.05, with tendencies declared at $P$-values between 0.05 and 0.10.

## RESULTS

*Forage yield*

Yield (DM basis) of the oat, radish, and turnip mixture in early November and the portion of total DM that each component comprised is presented in Figure 3.2. There was a yr effect ($P$ < 0.01) as yield in yr 1 was less ($P$ < 0.01) than yr 2 (3756 and 5144 kg/ha, respectively; SEM = 367 kg/ha). This difference is primarily due to the additional growing degree days (GDD; base 10°C) in yr 2 (587 GDD) since the mix was planted 17d earlier than in yr 1 (251 GDD). There was a yr by spp. interaction ($P$ < 0.01) for the proportion of total DM that each component comprised. However, in both years oat made up the greatest ($P$ < 0.01) proportion (57% of DM), followed by turnip tops (22% of DM), and then radish tops (13% of DM); whereas the turnip root (5.0% of DM) and radish root (2.8% of DM) did not differ ($P \geq 0.30$) and made up the least amount of DM (SEM ± 1.09; Figure 3.2).

*Grazing performance*

When comparing CRD and OBF during the grazing period, there was no yr × backgrounding treatment interaction ($P \geq 0.60$) for final grazing BW or ADG. There was a treatment effect ($P < 0.01$) for grazing ADG, with steers grazing OBF having greater ($P < 0.01$) ADG than CRD (Table 3.3). There was an effect of yr ($P < 0.01$) on ADG, with greater ($P < 0.01$) ADG being observed in yr 1 than yr 2 (0.82 and 0.35 ± 0.029 kg/d, respectively).

Mineral and monensin intake of grazing steers can be found in Figure 3.3. There was a yr × treatment interaction (P < 0.01) for mineral and monensin intake. In yr 1 steers on the CRD treatment had a greater (P < 0.01) consumption of mineral (173 g/d) and thus monensin (228 mg/d) than OBF steers (121 g/d of mineral and 160 mg/d of monensin). However, mineral (97 g/d) and monensin (129 mg/d) intake of CRD and OBF steers was not different (P = 0.25) in yr 2.

*Growing performance*

The growing period was targeted to end when steers reached 364 kg BW, and includes the grazing period plus the subsequent feeding of the corn silage-based diet for OBF and CRD. Steer growth performance for all 3 treatments during the growing period is presented in Table 3.4. There was no yr × backgrounding treatment interaction ($P \geq 0.17$) for growing ADG or final growing BW. There was a yr effect ($P < 0.01$) on growing period ADG with steers in yr 1 having greater ($P < 0.01$) ADG than steers during yr 2. There was also a treatment effect ($P < 0.01$) on growing period ADG with DCS steers having the greatest ($P < 0.01$) ADG, ADG of CRD steers being least ($P < 0.01$) and OBF steers being intermediate differing ($P < 0.01$) from both DCS and

CRD (Table 3.4). Average daily gain of the DCS steers during the backgrounding phase was used to estimate how many days CRD and OBF steers needed to be fed the corn silage-based diet to reach 364 kg. However the d needed to reach the target BW was overestimated as there was a treatment effect ($P < 0.01$) for final growing period BW with OBF having a greater ($P < 0.01$) final growing period BW than both CRD and DCS, with CRD tending to be greater ($P = 0.06$) than DCS (Table 3.4).

*Finishing performance*

There was a yr × backgrounding treatment interaction ($P < 0.01$) for carcass adjusted ADG and final BW (Table 3.5). In yr 1, there was no difference ($P > 0.30$) in carcass adjusted ADG among treatments during finishing, resulting in the initial finishing BW ranking to be maintained throughout finishing. With carcass adjusted final BW in yr 1 being greater ($P < 0.01$) for OBF than DCS and CRD, which did not differ ($P = 0.40$). In yr 2, the lesser ADG for CRD and OBF during the growing phase resulted in compensatory gain during the finishing phase, with finishing ADG not differing ($P = 0.12$) between CRD and OBF, but being greater ($P < 0.01$) than DCS. This resulted in a change from the initial finishing BW ranking, with carcass adjusted final BW not differing ($P = 0.26$) between OBF and CRD, but both being greater ($P < 0.01$) than DCS.

There was a yr × background treatment interaction ($P < 0.01$) for DMI. However, DMI of CRD and OBF steers within both yr did not differ ($P = 0.40$), but were greater ($P < 0.01$) than DCS steers. There was no yr × background treatment interaction ($P = 0.28$) for G:F but there was a significant effect of treatment ($P < 0.01$: SEM ± 0.0015 kg/kg) with G:F of DCS (0.162 kg/kg) being greater ($P < 0.01$) than CRD (0.153) and OBF (0.153 kg/kg) which did not differ ($P =$

0.79). There was a yr effect ($P < 0.01$) on G:F with yr 1 having greater ($P < 0.01$) feed efficiency than yr 2 (0.159 and 0.152 kg/kg, respectively; SEM = 0.0012 kg/kg).

*Carcass characteristics*

Carcass data are summarized in Table 3.6. Neither 12$^{th}$ rib fat nor marbling score had a yr × background treatment interaction ($P \geq 0.24$). There was no difference ($P = 0.89$) among treatments for 12$^{th}$ rib fat. However, there was a tendency for a yr effect ($P = 0.06$) with twelfth rib fat thickness tending to be less ($P = 0.06$) in yr 1 than yr 2. Marbling score had a treatment effect ($P = 0.04$) as DCS (429) was greater ($P = 0.01$) and OBF (424) tended to be greater ($P = 0.10$) than CRD (414) with DCS and OBF not differing ($P = 0.30$). Like rib fat, marbling score had a yr effect ($P < 0.01$) and was less ($P <0.01$) in yr 1 than in yr 2.

There was a yr × background treatment interaction ($P \leq 0.02$) for HCW and LM area. In yr 1, HCW of OBF was greater ($P < 0.01$) than both CRD and DCS which did not differ ($P = 0.40$). This difference in HCW is most likely a result of differences in initial finishing BW in yr 1. However in yr 2, HCW of OBF and CRD did not differ ($P = 0.26$), but were greater ($P < 0.01$) than DCS, despite the fact that CRD entered the finishing phase at a lighter BW than OBF. There was a yr effect ($P < 0.01$) as HCW across all treatments were greater ($P < 0.01$) in yr 1 than yr 2. The LM area of CRD and OBF steers within both yr did not differ ($P = 0.40$), but were greater ($P < 0.01$) than steers placed directly in the drylot (DCS).

There was a tendency for a yr × background treatment interaction ($P = 0.08$) for calculated YG. In yr 1, calculated YG of OBF and DCS steers did not differ ($P = 0.91$) but were greater ($P < 0.05$) than CRD steers. However, in yr 2, calculated YG was not different ($P \geq 0.22$) among all 3 treatments.

## DISCUSSION

### *Growing performance*

The ADG of steers was greater in yr 1 than in yr 2 for all treatments, which is most likely a result of weather differences between the yr. Interestingly, the differences among treatments within yr were consistent, with DCS having 0.415 kg/d greater gain than OBF which had 0.185 kg/d greater gain than CRD steers. The yr differences observed for growing phase ADG is most likely due to the fewer number of precipitation incidents during the growing period in yr 1 than yr 2. According to data compiled by The Weather Company LLC. in Hastings, NE, (29 km Northwest) temperature was slightly cooler in November (-6.0°C avg. min. and 8.7°C avg. max.) and December (-5.3°C avg. min. and 3.3°C avg. max.) in yr 1 than in November (0.67°C avg. min. and 12.1°C avg. max.) and December (-4.2°C avg. min. and 5.4°C avg. max.) of yr 2. However, in yr 1 there was very little precipitation (0.58 cm, November and 1.37 cm, December) and only 1 incident of freezing rain; whereas in yr 2 there was more precipitation (5.16 cm, November and 5.54 cm, December), with 6 incidents of freezing rain and 1 incident of ice pellets. The increased number of precipitation events in yr 2 may have increased maintenance energy requirements; as steers would have needed to use more energy to maintain body temperature, due to reduced external insulation as a result of damp hair coats (NRBC, 2016).

### *Expected grazing performance*

Expected performance of steers grazing oat-brassica forage is challenging to assess, because of the lack of published research. The digestibility of late-summer planted oats and brassicas in this study was quite high (89 and 83% IVOMD with 19 and 26% ADF, for yr 1 and 2, respectively) and the CP content although variable was also high, ranging from 25% in yr 1 to 16% in yr 2. These value are consistent with previously observed values for summer plants oats and brassicas (Koch et al., 2002; Villalobos and Brummer, 2015; Coblentz and Cavadini, 2016). The ADG of steers grazing OBF in the present study ranged from 1.15 kg/d in yr 1 to 0.49 kg/d in yr 2. Smart et al. (2006) reported similarly high quality forage for rye (21% ADF and 18% CP) and turnips (13 and 12% ADF; 24 and 14% CP for tops and roots, respectively) when planted in late July near Brookings, SD. Heifers grazing a mix of turnips and rye (reported to consist mainly of turnips) during October and November had an ADG of 0.56 kg/d and those grazing a monoculture of rye gained 0.72 kg/d (Smart et al., 2006). Steers grazing an oats monoculture (78.9% IVOMD, 25.6% ADF and 18% CP) near Mead, NE (approximately 160 km Northeast of Clay Center, NE) during a similar time period (November and December) as grazing occurred in yr 2 of the present study had an ADG of 0.59 kg/d (Ulmer et al., 2017). Thus the lower gains in yr 2 are within the range that has been previously reported but gains in yr 1 were much greater than previous reports.

Grazing corn residue is an excellent way to utilize harvested corn ha abundantly available in the Midwest for beef cattle production. In Nebraska alone 4 million ha of corn grain were planted in 2016 (USDA NASS, 2016). This opportunity especially holds true for farmer-feeders that manage a combination of farm ground and cattle. However, solely grazing corn residue will not meet the maintenance requirements of growing calves let alone allow for gains. Metabolizable protein is generally the first limiting nutrient of growing calves grazing corn residue, although, to achieve moderate or high rates of gain supplemental energy is also needed (Fernandez-Rivera and Klopfenstein, 1989b; Tibbitts et al., 2016). Distillers grains are high in CP (31%) with the majority of the CP being RUP (68% of CP) and thus is a good source of metabolizable protein. Distillers grains are also a good source of energy as they contain more net energy than corn grain (NRBC, 2016). Based on a pooled analysis of three trials in which steers grazing corn residue and were supplemented with distillers grains at amounts ranging from 0.68 to 3.0 kg/steer over a three year period (Welchons and MacDonald, 2017), the gains of CRD steers would have been predicted to be 0.74 kg/d. The ADG of CRD in yr 1 (0.69 ± 0.056 kg/d), appears to fit this model. However, the ADG (0.20 ± 0.14 kg/d) of CRD in yr 2 was only a third of what would have been predicted using this model.

*Finishing performance*

Previous studies, have suggested that growing phase ADG is negatively correlated with finishing phase ADG and G:F (Reuter and Beck, 2012; Lancaster et al., 2014). The increased finishing ADG observed for CRD and OBF steers compared to DCS in yr 2 are consistent with these studies. However in yr 1, no difference in finishing ADG was observed among treatments. It is unclear why a greater finishing phase ADG was only observed in yr 2 as the relative difference in growing phase ADG among treatments was similar among years. However, yr 1 gains of all treatments where greater than in yr 2 as a result of increased maintenance energy requirements due to weather during the growing period in yr 2.

In both yr, finishing DMI was greater (6 and 20% in yr 1 and 2, respectively) and G:F was lesser (4 and 7% in yr 1 and 2, respectively) for the two grazing treatments (OBF and CRD) when compared to DCS. The study design was intended to evaluate the effect of the 3 backgrounding treatments when placed in the finishing phase at the same BW. However, in both yr feedlot placement BW was greatest for OBF steers, whereas CRD and DCS did not differ in yr 1, and CRD was greater than DCS in yr 2. Increased feedlot placement BW has been shown to be correlated with an increase in finishing DMI and lesser G:F (Reuter and Beck, 2013; Lancaster et al., 2014). However, the differences in feedlot placement BW were relatively small with the greatest difference being 24 kg, between OBF and DCS in yr 2. Given that CRD and DCS placement wt and final BW did not differ in yr 1, this does not completely explain the DMI and G:F differences observed.

McCurdy et al. (2010) indicated that growing phase management may influence finishing phase G:F. They reported that finishing G:F was 20% greater for steers grown on a sorghum silage diet fed ad libitum and steers limit fed a high-concentrate diet than steers grazing winter wheat pasture. All 3 treatments were not different in growing phase ADG (1.14 kg/d), feedlot placement age, or feedlot placement BW (376 kg). McCurdy et al. (2010) suggested that stress due to shipping steers from wheat pasture to the feedlot and adapting them to the pen, bunk, and water could have caused the observed decrease in G:F for the steers grazing wheat. These results are very similar to finishing G:F differences in the present study; in which grazing steers during the growing phase had a lesser finishing G:F than steers consuming a corn silage-based ration in pens. In the present study, both CRD and OBF were hauled from the drylot to their fields and then were trailed by horse from the field to the drylot pens (approximately 2.72 km for CRD and 6.35 km for OBF in yr 1 and 3.50 km for CRD and 4.34 km for OBF in yr 2).

*Carcass characteristics*

In the present study, 12$^{th}$ rib back fat did not differ among treatments. However, CRD had a slight reduction in marbling. The majority of studies evaluating the effects of backgrounding systems on marbling score have found no impact if cattle are slaughtered at similar 12$^{th}$ rib fat thickness (Hill et al., 1996; Lancaster et al., 2014). Regression models created by Reuter and Beck (2012) and Lancaster et al. (2014) also indicated that growing phase ADG was not correlated with marbling score. However, when McCurdy et al. (2010) compared backgrounding steers by grazing winter wheat pasture, feeding a sorghum silage diet, or limit feed a high-concentrate diet, steers that grazed winter wheat during the growing period had a slight reduction in marbling score (409) compared to steers that had been fed the sorghum silage diet and those limit-fed a concentrate diet (449 and 423, respectively) during the growing period despite the fact that 12$^{th}$ rib fat thickness at harvest did not differ among treatments. Again, McCurdy et al. (2010) suggested that stress due to shipping of the steers grazing wheat pasture could have caused the observed decrease in marbling score. Since intramuscular fat (marbling) develops at similar rates over a calf's lifetime and that in times of stress there is an elevation in catecholamine hormone which causes lipolysis (Pethick and Dunshea, 1996; Pethick et al. 2004). In the present study, however, both OBF and CRD were treated similarly in terms of movement to and from the fields. The CRD steers did, however, have to learn how to graze corn residue. The concept of learned grazing behavior for calves grazing corn residue was demonstrated by Summers et al. (2013), when they observed that heifer calves that previously grazed corn residue prior to breeding had greater ADG (0.41 kg/d) post breeding while grazing corn residue than heifers developed in a drylot or heifers developed on winter range, and grazing corn residue post breeding (0.30 and 0.34 kg/d, respectively). They concluded that heifers learned which plant parts to select for when developed on corn residue, which allowed them to more quickly adapt to grazing corn residue as pregnant heifers compared to pregnant heifers developed on either winter range or in the drylot. Calves in the present study had not grazed corn residue prior to starting the trial and it could have taken them some time to adjust to grazing this forage source (learning which plant parts to select). This may have resulted in a period of time in which energy intake was not sufficient to maintain similar amounts intramuscular fat deposition as the other treatments. However, it is important to note, that the difference observed in the present study for marbling score were minor and not great enough to merit a difference in price discounts or premiums for carcasses (all treatments were in the slight$^{00}$ category for marbling score).

Both of the grazing treatments had a greater HCW and LM area than DCS. Feedlot placement BW may partially explain the greater HCW of the grazing treatments. Lancaster et al. (2014) indicated that calves entering the feedlot at a greater BW were likely to have a greater HCW at harvest and that HCW has a strong positive relationship ($R^2 = 0.86$) with LM area.

In conclusion, weather can have a large impact on the expected rate of growth when backgrounding calves over the winter in the Midwest. Grazing steers on corn residue and supplemented with 0.86% BW of distillers grain or grazing an oats-brassica forage mix did increase finishing DMI and decrease G:F compared to feeding a corn silage-based diet during the backgrounding period. Marbling of steers grazing corn residue and supplemented with distillers grains was lesser than those grazing the oat-brassica forage mix and those fed the corn silage-based ration. However, according to the results from this study, these grazing systems can be used without causing noteworthy detrimental effects on carcass characteristics.

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**Table 3.1. Composition of growing and finishing diet**

| Item | Growing Diet DM basis, % | Finishing Diet DM basis, % |
|---|---|---|
| Ingredient | | |
| Dry Rolled Corn | -- | 55.8 |
| Corn Silage | 51.0 | 8.7 |
| Alfalfa Hay | 25.0 | -- |
| WDGS[1] | 20.0 | 32.3 |
| Supplement[2] | 4.0 | 3.2 |
| Analyzed composition | | |
| Crude Protein, % | 16.2 | 17.5 |
| NEm, Mcal/kg | 1.65 | 4.73 |
| NEg, Mcal/kg | 1.04 | 3.26 |

[1]Wet distillers grains plus solubles.
[2]Supplement provided Rumensin (Purina Animal Nutrition LLC., Gray Summit, MO) at 31 g/t of diet DM.

**Table 3.2. Two-year crude protein (CP) and in vitro DM digestibility (IVDMD) of the oat-brassica forage1**

| | Oat | Radish | | Turnip | | Total[2] |
|---|---|---|---|---|---|---|
| Item | | Root | Leaf | Root | Leaf | |
| Year 1 | | | | | | |
| CP, % | 23 | 20 | 30 | 23 | 28 | 25 |
| IVDMD, % | 84 | 94 | 90 | 94 | 92 | 89 |
| Year 2 | | | | | | |
| CP, % | 13 | 16 | 26 | 11 | 21 | 16 |
| IVDMD, % | 76 | 97 | 92 | 98 | 94 | 83 |

[1]Brassicas (radish and turnip) were separated into root and leaf after collection and before nutrient analysis.
[2]Total is calculated based proportions of each component available.

**Table 3.3. Two-year performance of steers grazing corn residue plus supplemented with dry distillers at 0.86% of BW (CRD) or grazing fall planted oat and brassicas forage (OBF) from mid-November to mid-January**

| Item | CRD | OBF | SEM[2] | *P*-value[1] |
|---|---|---|---|---|
| Initial BW, kg | 286 | 285 | 1.2 | 0.30 |
| Final grazing BW, kg | 315[b] | 331[a] | 1.8 | <0.01 |
| ADG, kg | 0.45[b] | 0.72[a] | 0.028 | <0.01 |

[1]There were no yr × treatment interactions ($P \geq 0.60$).
[2]Standard error of the least squares mean (n = 8 replicates/mean).
[a,b]Means within a row lacking common superscript differ.

**Table 3.4. Two-year growing performance of steers grazing either corn residue and supplemented with dry distillers at 0.86% of BW (CRD) or fall planted oat and brassica forage (OBF) for 65 or 66 d (yr 1 and 2, respectively) then being fed a corn silage-based diet for 21 or 33 d (yr 1 and 2, respectively), or being fed a corn silage-based diet in the drylot (DCS) for 54 d or 52 d (yr 1 and 2, respectively)**

| Item | CRD | OBF | DCS | SEM[2] | *P*-value[1] |
|---|---|---|---|---|---|
| Growing Period[3] | | | | | |
| Initial BW, kg | 286 | 285 | 283 | 1.3 | 0.13 |
| Final growing BW, kg | 366[b] | 381[a] | 361[b] | 1.8 | <0.01 |
| ADG, kg | 0.87[c] | 1.05[b] | 1.48[a] | 0.022 | <0.01 |

[1]There were no yr by treatment interactions ($P \geq 0.17$).

[2]Standard error of the least squares mean (n = 8 pens/mean).

[a,b,c]Means within a row lacking common superscript differ.

**Table 3.5. Two-year finishing performance of steers backgrounded by grazing corn residue and supplemented with dry distillers grains at 0.86% of BW (CRD), grazing a fall oat and brassica forage (OBF), or fed a corn silage-based backgrounding diet in drylot (DCS)**

| | Treatments | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | | | Year 2 | | | | *P* - Value | | |
| Item | CRD | OBF | DCS | CRD | OBF | DCS | SEM[2] | Year | Treatment | Yr*Trt[2] |
| Initial finishing BW, kg | 365[b] | 381[a] | 365[b] | 367[b] | 381[a] | 357[c] | 2.5 | 0.43 | <0.01 | 0.18 |
| Final live BW[3], kg | 608[b] | 625[a] | 614[b] | 616[a] | 622[a] | 570[b] | 4.0 | <0.01 | <0.01 | <0.01 |
| Final BW[4], kg | 627[b] | 648[a] | 631[b] | 640[a] | 645[a] | 593[b] | 3.4 | <0.01 | <0.01 | <0.01 |
| DMI, kg | 10.2[a] | 10.3[a] | 9.6[b] | 10.9[a] | 10.7[a] | 9.0[b] | 0.13 | 0.12 | <0.01 | <0.01 |
| ADG[4], kg | 1.64[a] | 1.67[a] | 1.67[a] | 1.71[a] | 1.66[a] | 1.47[b] | 0.022 | 0.01 | <0.01 | <0.01 |
| G:F[4], kg/kg | 0.161[b] | 0.162[b] | 0.174[a] | 0.157[ab] | 0.155[b] | 0.162[a] | 0.0021 | <0.01 | <0.01 | 0.28 |

[1]Standard error of the least squares mean (n = 4 reps/year).
[2]Year by background treatment interaction.
[3]BW were taken prior to feeding on the day they were hauled to the packing plant, with a calculated 4% shrink.
[4]Carcass adjusted final BW, ADG, and G:F using a common dressing percent of 62%.
[a,b,c]Means within item and yr lacking common superscript differ.

**Table 3.6. Carcass characteristics of steers backgrounded by grazing corn residue and supplemented with dry distillers grains at 0.86% of BW (CRD), grazing a fall oat and brassica forage (OBF), or fed a corn silage-based backgrounding diet in drylot (DCS)[1]**

| | Treatments | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | | | Year 2 | | | | *P* -Value | | |
| Item | CRD | OBF | DCS | CRD | OBF | DCS | SEM[1] | Year | Treatment | Yr*Trt[2] |
| HCW, kg | $389^b$ | $402^a$ | $391^b$ | $397^a$ | $400^a$ | $367^b$ | 2.14 | <0.01 | <0.01 | <0.01 |
| $12^{th}$ rib fat, cm | 1.48 | 1.55 | 1.54 | 1.68 | 1.57 | 1.58 | 0.053 | 0.06 | 0.89 | 0.24 |
| LM area, $cm^2$ | $85.2^a$ | $85.0^a$ | $82.7^b$ | $86.3^a$ | $87.3^a$ | $80.1^b$ | 0.71 | <0.44 | <0.01 | 0.02 |
| Calculated YG | $3.29^b$ | $3.48^a$ | $3.49^a$ | $3.54^a$ | $3.42^a$ | $3.52^a$ | 0.065 | 0.20 | 0.39 | 0.08 |
| Marbling score[3] | 402 | 419 | 423 | 426 | 428 | 435 | 7.7 | <0.01 | 0.04 | 0.35 |
| % Choice | $44^b$ | $59^a$ | $56^a$ | $58^a$ | $57^a$ | $63^a$ | 3.4 | <0.03 | 0.04 | 0.11 |

[1]Standard error of the least squares mean (n = 4 reps/year).

[2]Year by background treatment interaction.

[3]Marbling score: 400 = Slight$^{00}$, 450 = Slight$^{50}$, 500 = Small$^{00}$

[a,b]Means within a row and yr lacking common superscript differ.

**Figure 3.1. Study timeline, day of trial indicated in parentheses, with yr 1 represented first and yr 2 represented second. Steers assigned to the drylot treatment (DCS) were fed a corn silage-based diet for 54 d in yr 1 and 52 d in yr 2 before being implanted and transitioned to the finishing diet. Steers assigned corn residue and supplementation with dry distillers at 0.86% of BW (CRD) and those assigned fall planted oat and brassicas forage (OBF) grazed 65 d in yr 1 and 66 d in yr 2 and then were fed a corn silage-based diet for 21 d in yr 1 and 33 d yr 2 before being implanted and transitioned to the finishing diet. The finishing period lasted 160 days for all treatments in both years.**

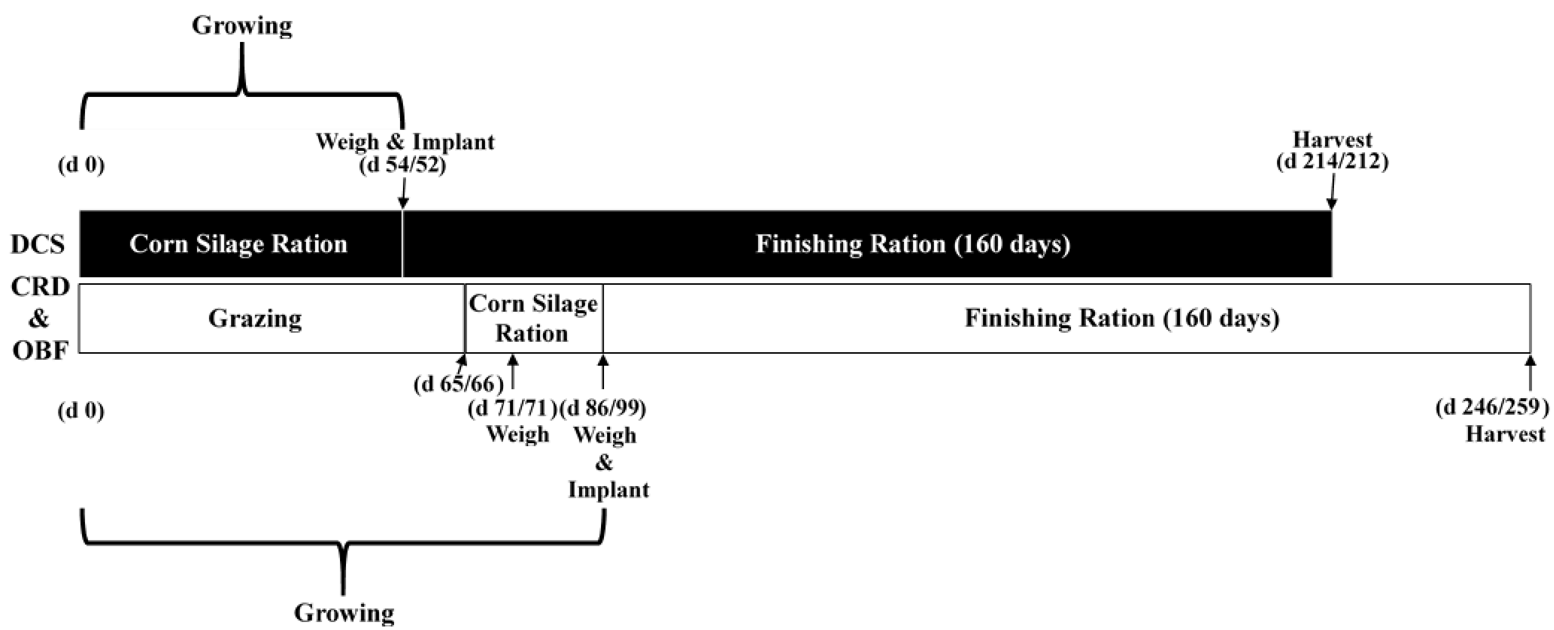


**Figure 3.2. Initial forage yield of double-crop forage mix (oat, turnip leaf and root, and radish leaf and root) planted after corn silage harvest. A) Total forage yield (kg/ha). B) Composition of mix components on DM basis. a,b,c,d Means within yr lacking common superscript differ.**

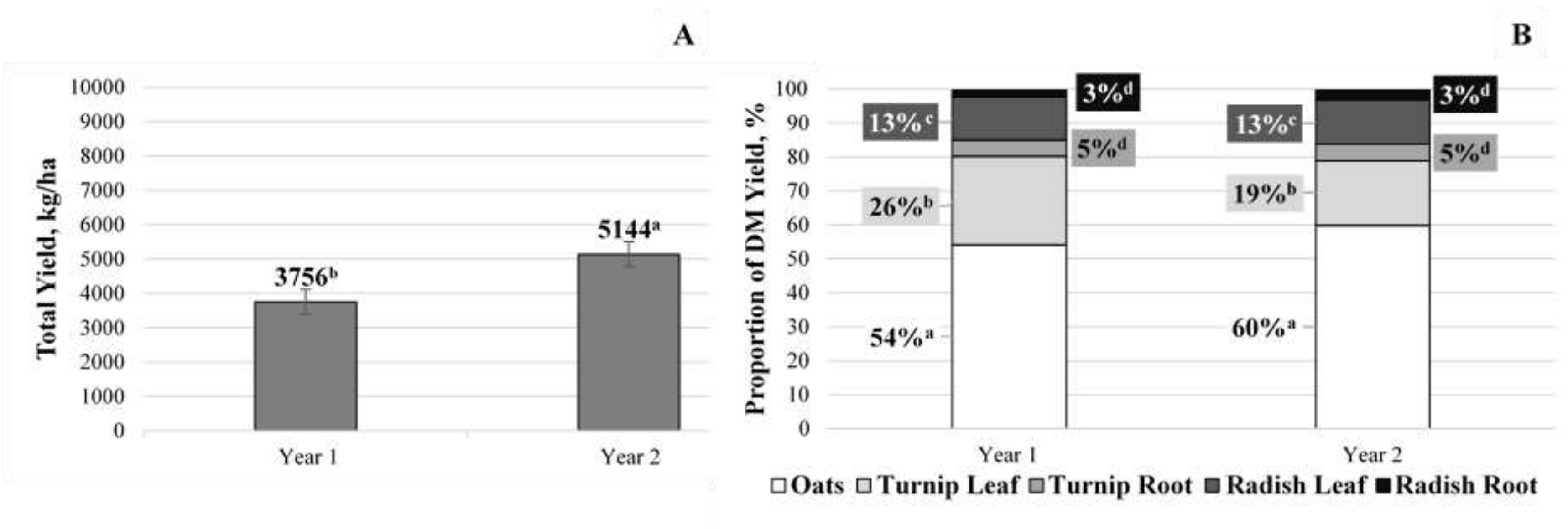
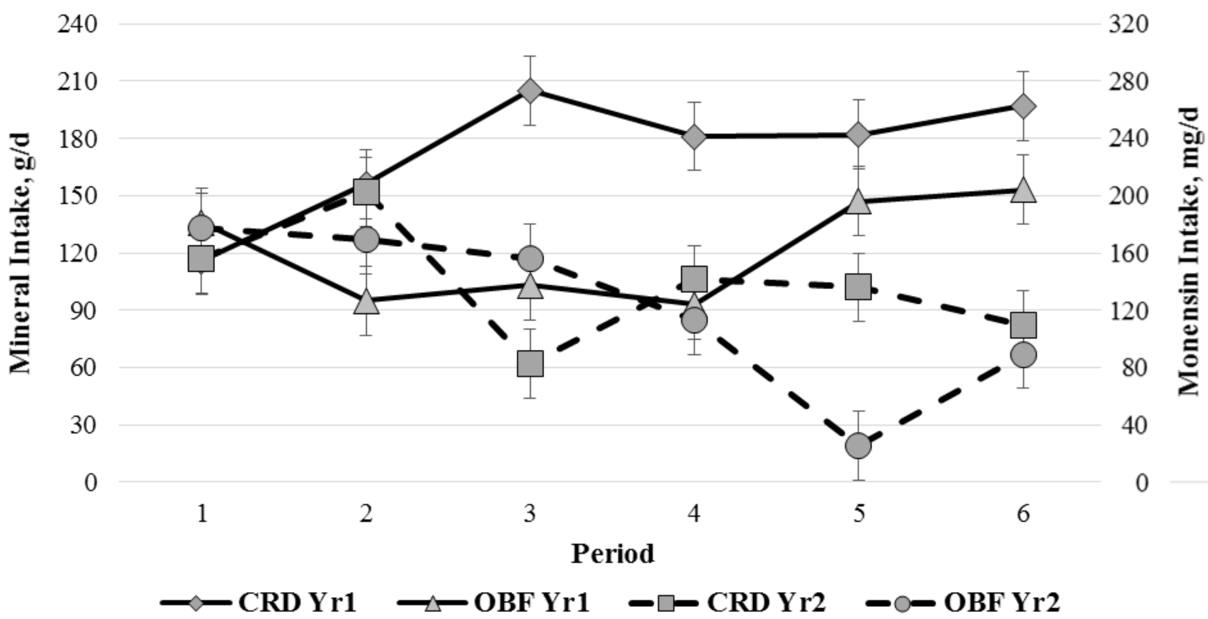


**Figure 3.3. Mineral (g per steer per d) and monensin (mg per steer per d) intake of steers grazing corn residue plus supplemented with dry distillers at 0.86% of BW (CRD) or grazing fall planted oat and brassicas forage (OBF) from mid-November to mid-January. Year by treatment by period interaction (*P* < 0.04).**



## APPENDIX

### I. Crop consultant Background Information

| Questions | Responses |
|---|---|
| **As a producer what is the number of acres of crops you directly farm?** [†] | **n (%)** |
| 0 crop acres | 57 (31.5) |
| 1-199 total crop acres | 39 (21.5) |
| 200-999 total crop acres | 43 (23.8) |
| 1,000-3,999 total crop acres | 30 (16.6) |
| 4,000 and greater total crop acres | 12 (6.6) |
| **Please indicate the percentage for total crop land that falls into the following categories (personal land).*** | **Mean ± SD** |
| Dryland | 2.9 ± 1.8 |
| Irrigated | 3.1 ± 1.7 |
| Irrigated by sprinkler | 3.3 ± 1.7 |
| Irrigated by furrow/surface | 1.4 ± 1.0 |
| Irrigated by sub-surface-drip | 1.0 ± 0.0 |
| Irrigated by other | 1.0.± 0.0 |
| **How many acres of crops do you influence/provide consulting for?** [£] | **n (%)** |
| 0 crop acres | 18 (8.5) |
| 1-199 total crop acres | 6 (2.8) |
| 200-999 total crop acres | 5 (2.4) |
| 1,000-3,999 total crop acres | 22 (10.4) |
| 4,000 and greater total crop acres | 160 (75.8) |
| **Please indicate the percent of total cropland you consult that falls into the following categories.*** | **Mean ± SD** |
| Dryland | 2.3 ± 1.4 |
| Irrigated | 3.5 ± 1.3 |
| Irrigated by sprinkler | 3.7 ± 1.3 |
| Irrigated by furrow/surface | 1.5 ± 0.1 |
| Irrigated by sub-surface-drip | 1.0 ± 0.4 |
| Irrigated by other | 1.0 ± 0.5 |
| **What percent of your clients use the following farm practices?*** | **Mean ± SD** |
| No till | 3.3 ± 1.3 |
| Ridge till | 1.7 ± 1.0 |
| Other | 2.3 ± 1.3 |
| **Do you recommend grazing corn residue?** [#] | **n (%)** |
| Yes | 178 (82) |
| No | 38 (18) |

[†]Missing n= 53
[£]Missing n=23
[#]Missing n=18;
*Response set is 1=0-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%

**II. Crop producer Background Information**

| Questions | Responses |
|---|---|
| **How many acres of crops do you directly farm? †** | **n (%)** |
| 0 crop acres | 7 (6.1) |
| 1-199 total crop acres | 23 (20.2) |
| 200-999 total crop acres | 45 (39.5) |
| 1,000-3,999 total crop acres | 35 (30.7) |
| 4,000 and greater total crop acres | 4 (3.5) |
| **Please indicate the percentage for total crop land that is each of the following.*** | **Mean ± SD** |
| Dryland | 3.2 ± 1.7 |
| Irrigated | 3.3 ± 1.6 |
| Irrigated by sprinkler | 3.3 ± 1.5 |
| Irrigated by furrow/surface | 1.4 ± 0.94 |
| Irrigated by sub-surface-drip | 1.0 ± 0.0 |
| Irrigated by other | 2.0.± 1.2 |
| **What is your primary farming practice?*** | **Mean ± SD** |
| No till | 4.4 ± 1.2 |
| Ridge till | 2.0 ± 1.3 |
| Other | 3.5 ± 1.7 |
| **How is your corn residue grazed? (select all that apply)** | **n (%)** |
| Grazed by my livestock | 51 (39.2) |
| Rented for grazing | 26 (20) |
| Not grazed | 53 (40.8) |

†Missing n=16

*Response set is 1=0-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%

**III. Dryland vs. irrigated acres influence on crop consultants and crop producer's decision/ behavior to recommend or allow grazing**

**Crop consultants that recommend grazing vs do not recommend grazing and the percentage of Dryland acres they influence.** [†]

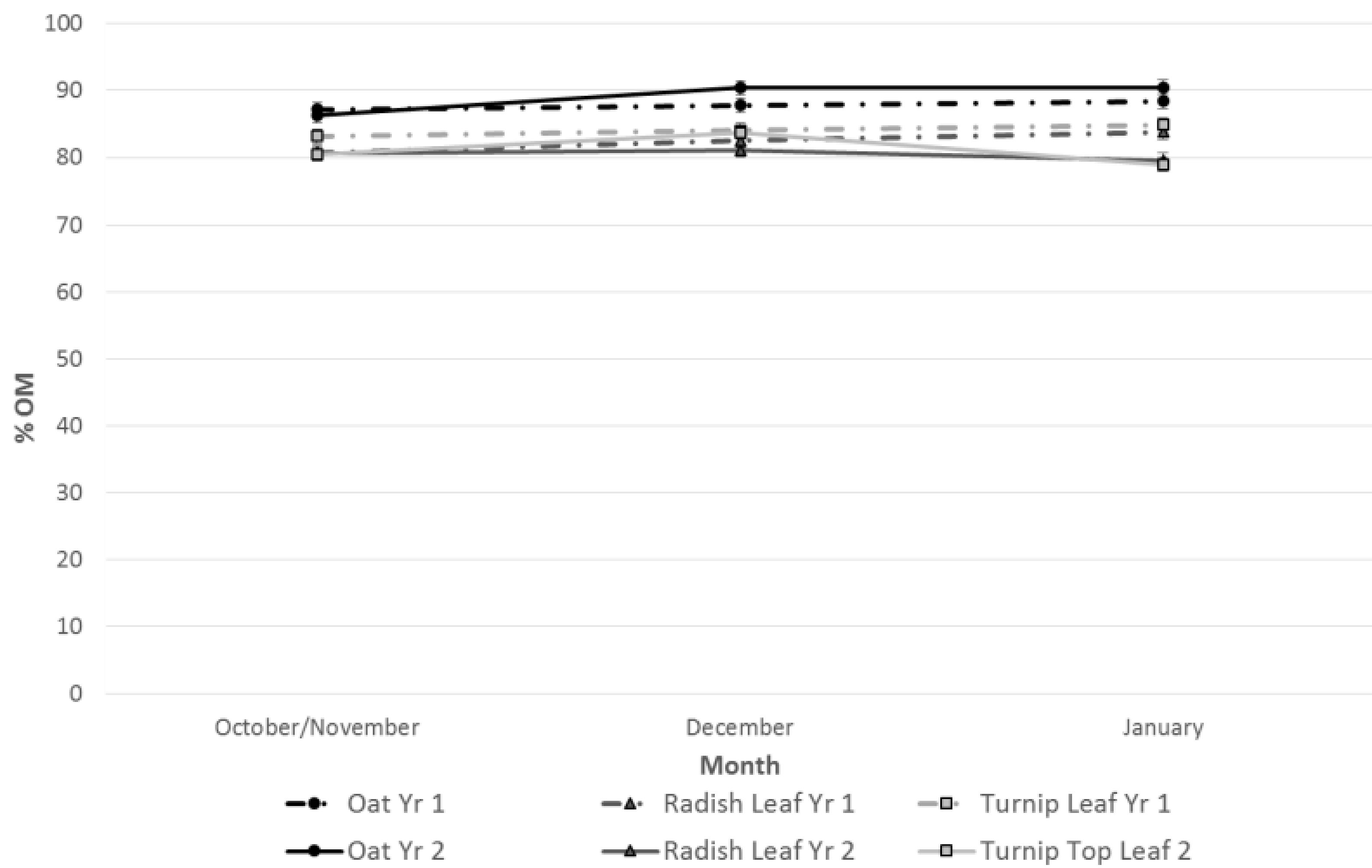
| | Yes, I Recommend Grazing (n=155) | No, I Do Not Recommend Grazing (n=33) | P - Value |
|---|---|---|---|
| Dryland Acres | 2.2 ± 1.3 | 2.8 ± 1.6 | -- |

**Crop producers that allow grazing vs do not allow grazing and the percentage of Dryland acres they farm.**

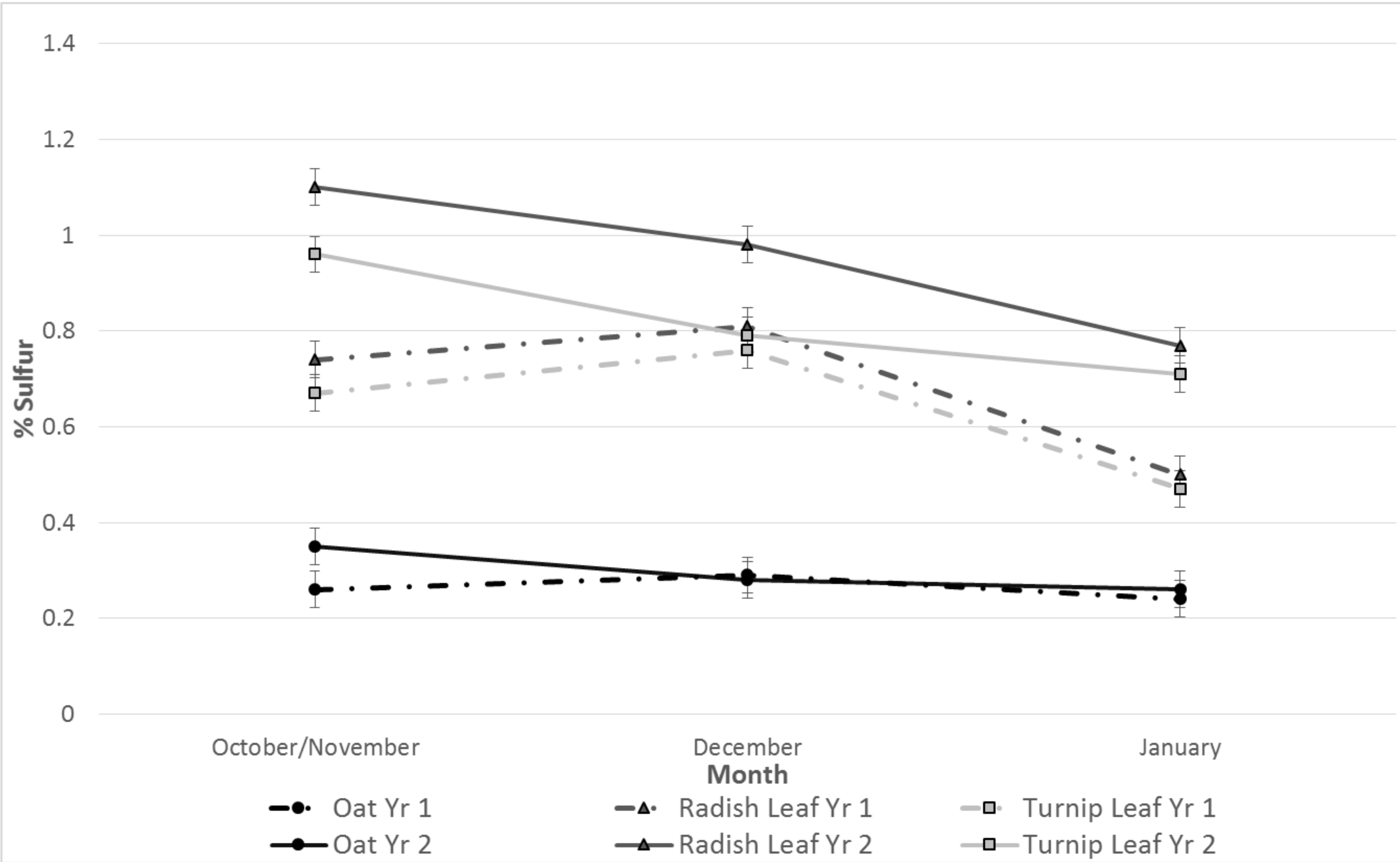
| | Allow Grazing (n=40) | Do Not Allow Grazing (n=44) | P - Value |
|---|---|---|---|
| Dryland Acres | 2.9 ± 1.8[a] | 3.7 ± 1.6[b] | <0.05 |

[†] Response set is 1=0-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%

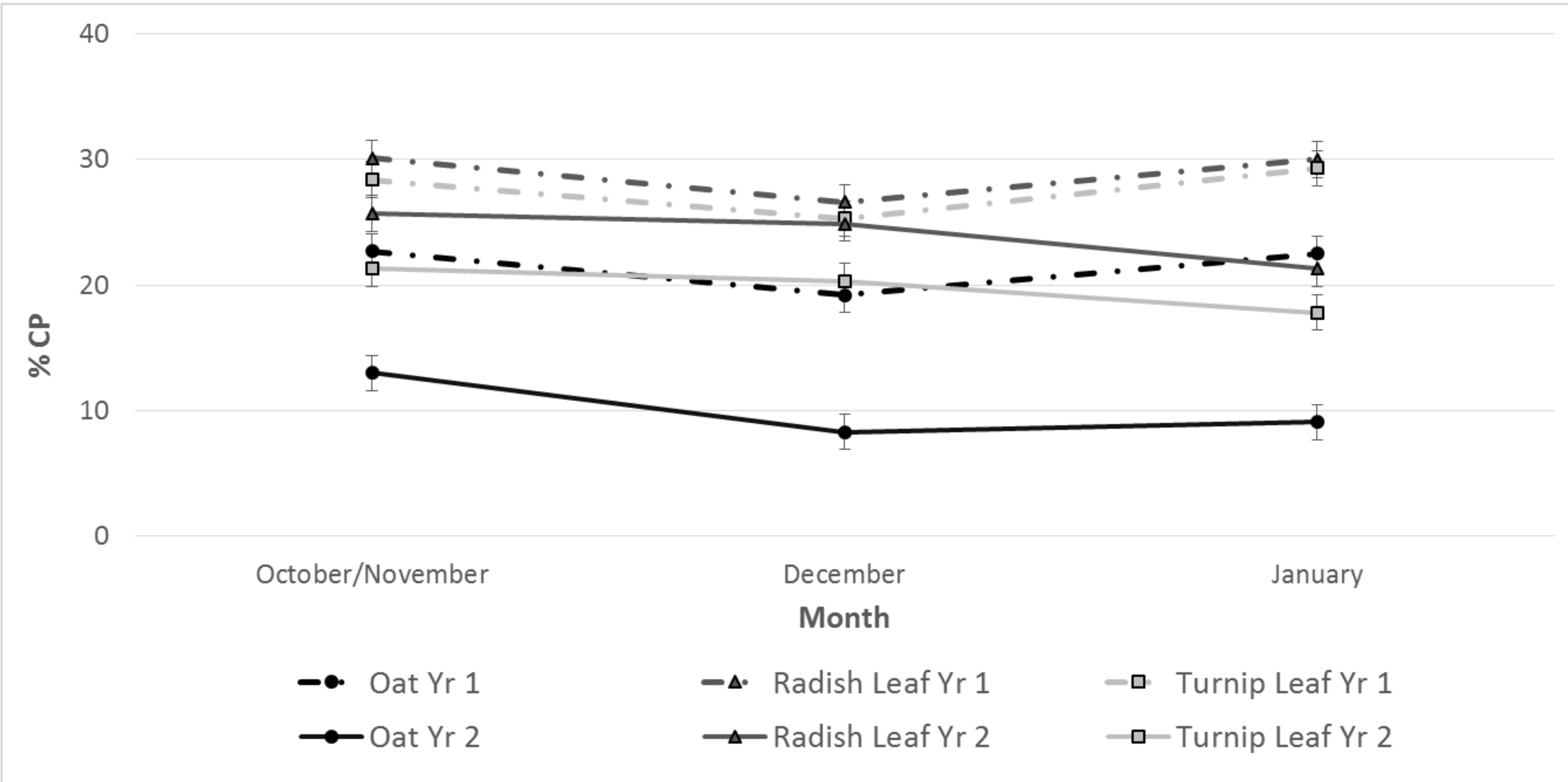
**IV. Percent organic matter (OM) on a DM basis over time of individual forage component in oat-brassica mix for yr 1 and yr 2**



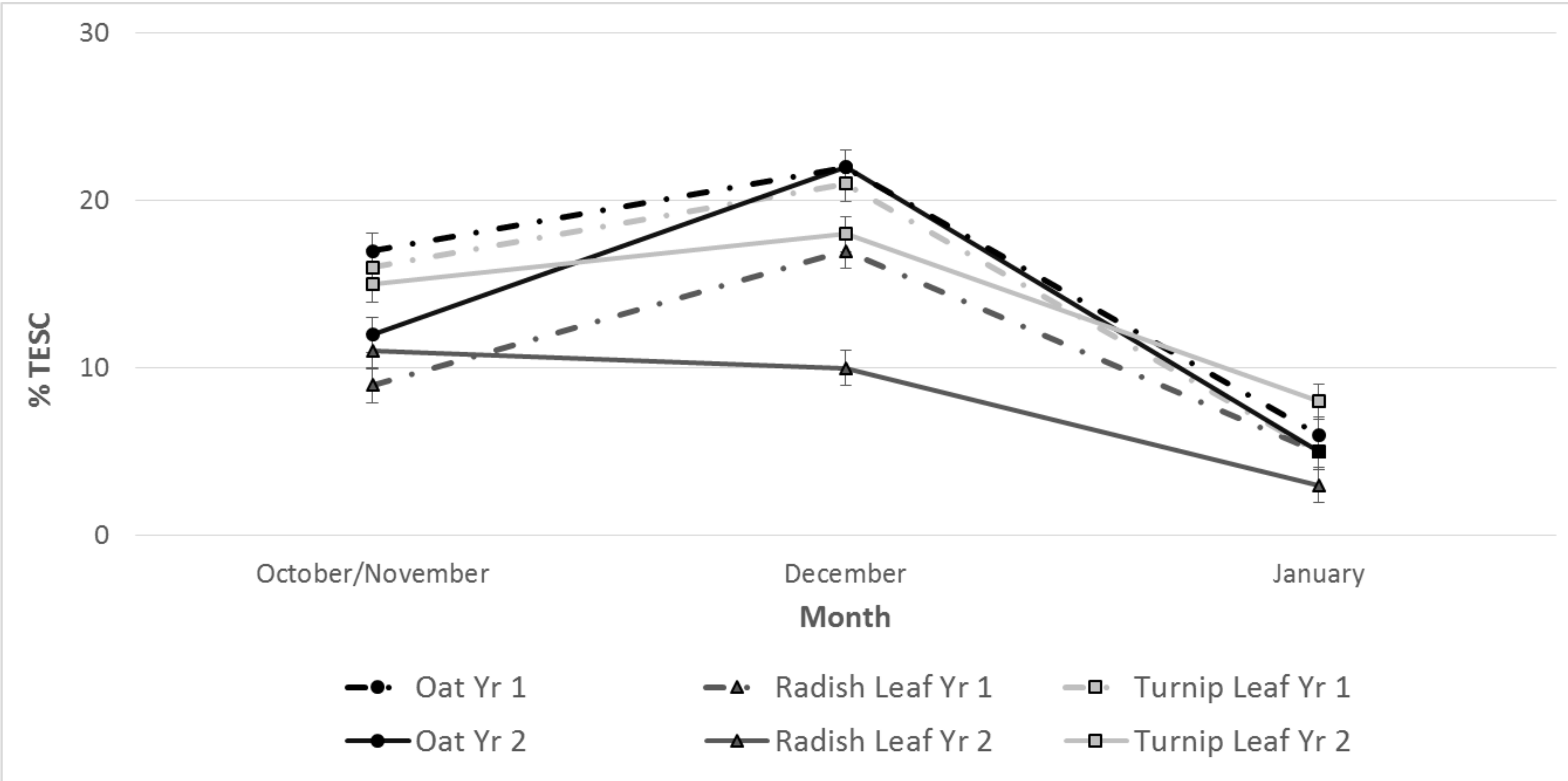
**V. Percent Sulfur on a DM basis over time of individual forage component in oat-brassica mix for yr 1 and yr *2***



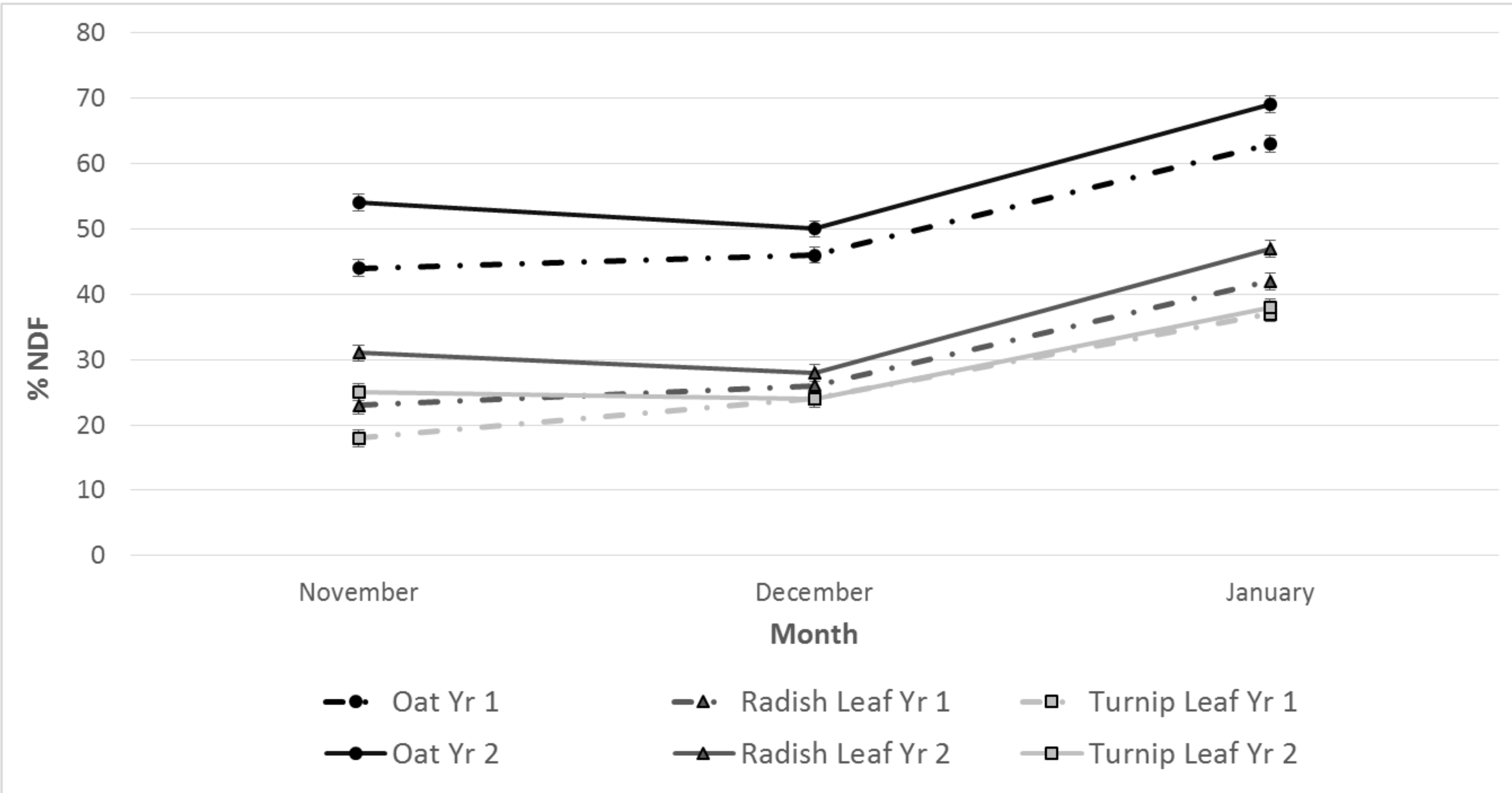
**VI. Percent crude protein (CP) on a DM basis over time of individual forage component in oat-brassica mix for yr 1 and yr 2**



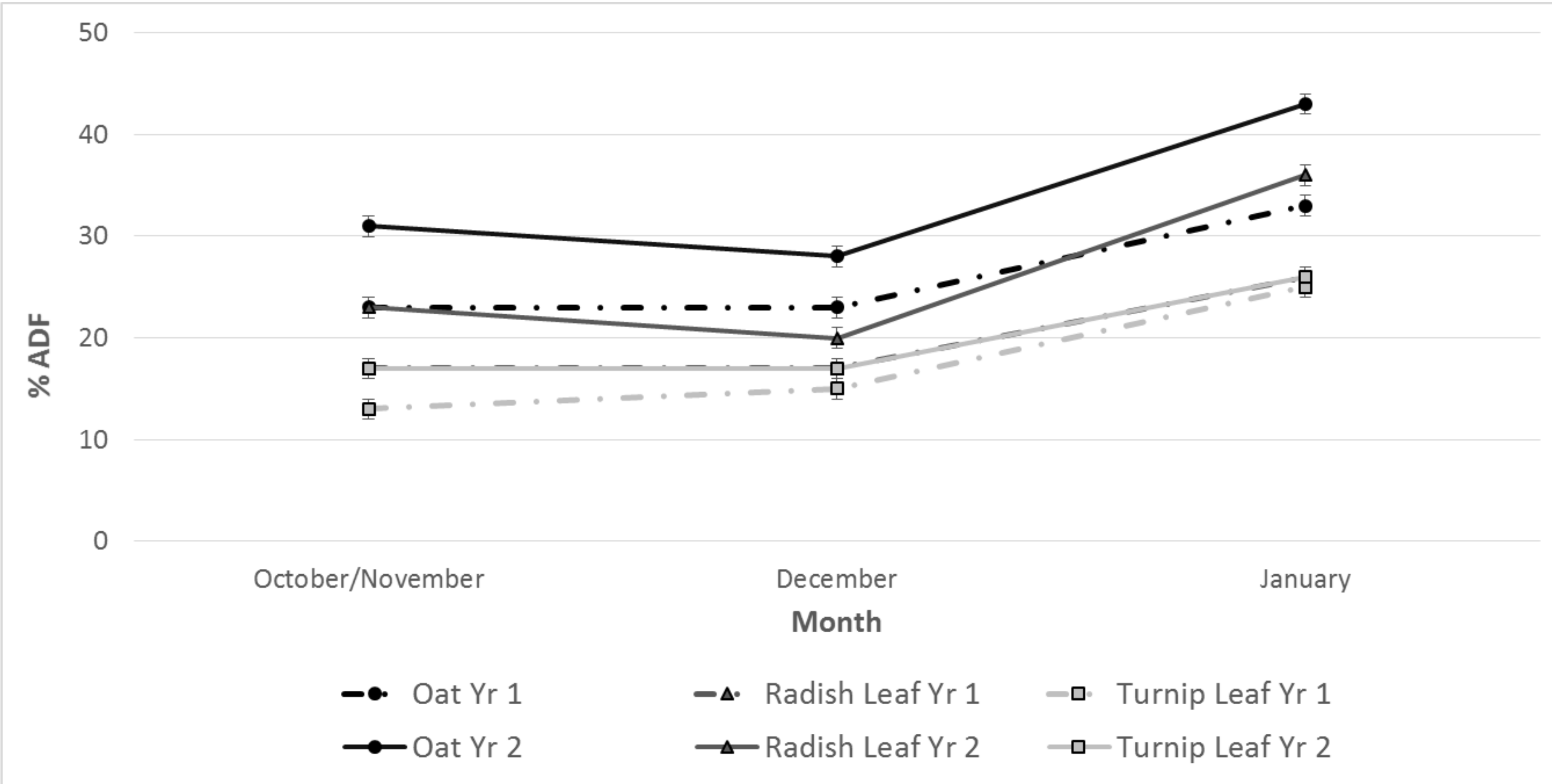
**VII. Percent total ethanol soluble carbohydrates (TESC) on a DM basis over time of individual forage component in oat-brassica mix for yr 1 and yr 2**



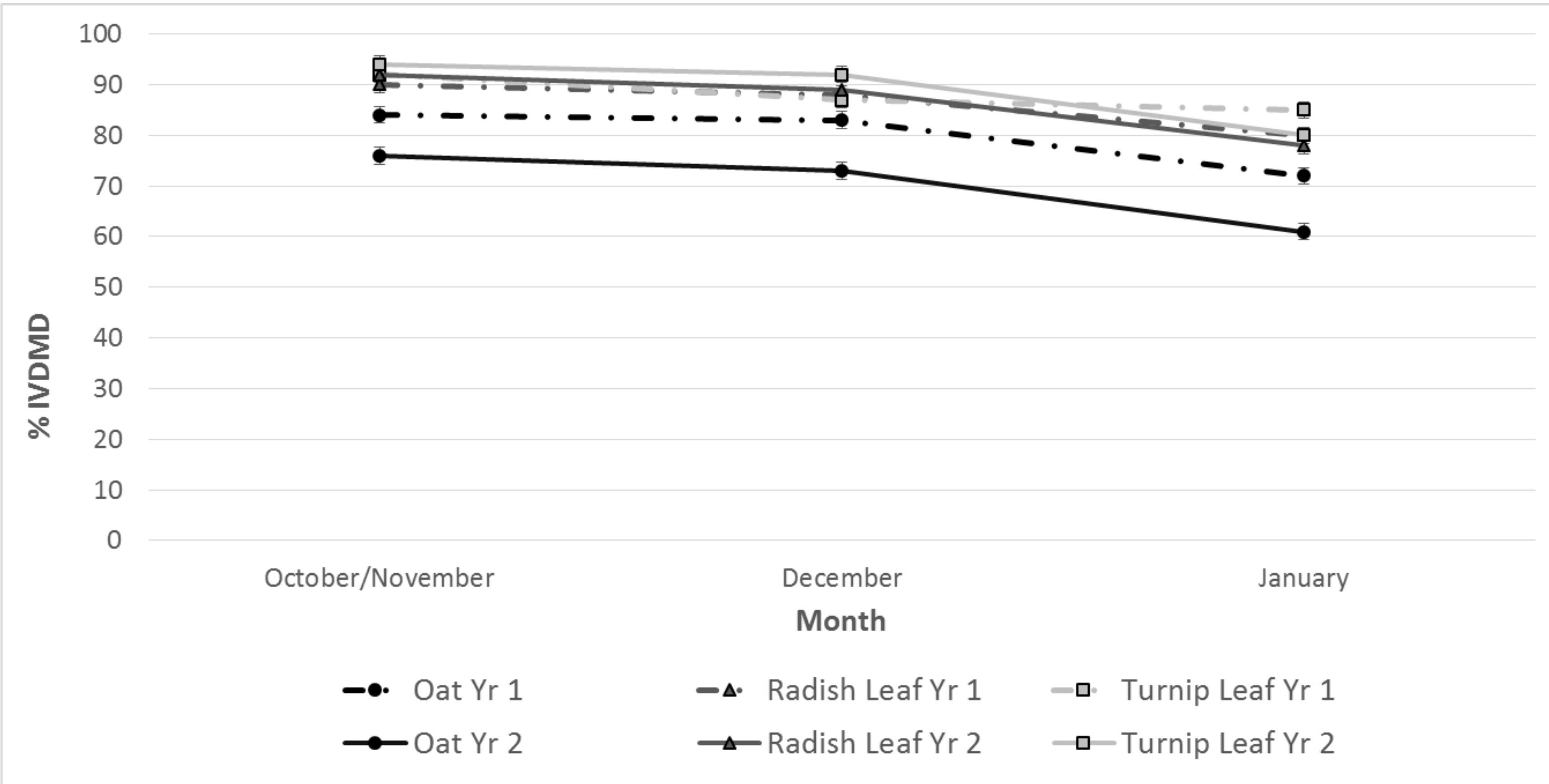
**VIII. Percent neutral detergent fiber (NDF) on a DM basis over time of individual forage component in oat-brassica mix for yr 1 and yr 2**



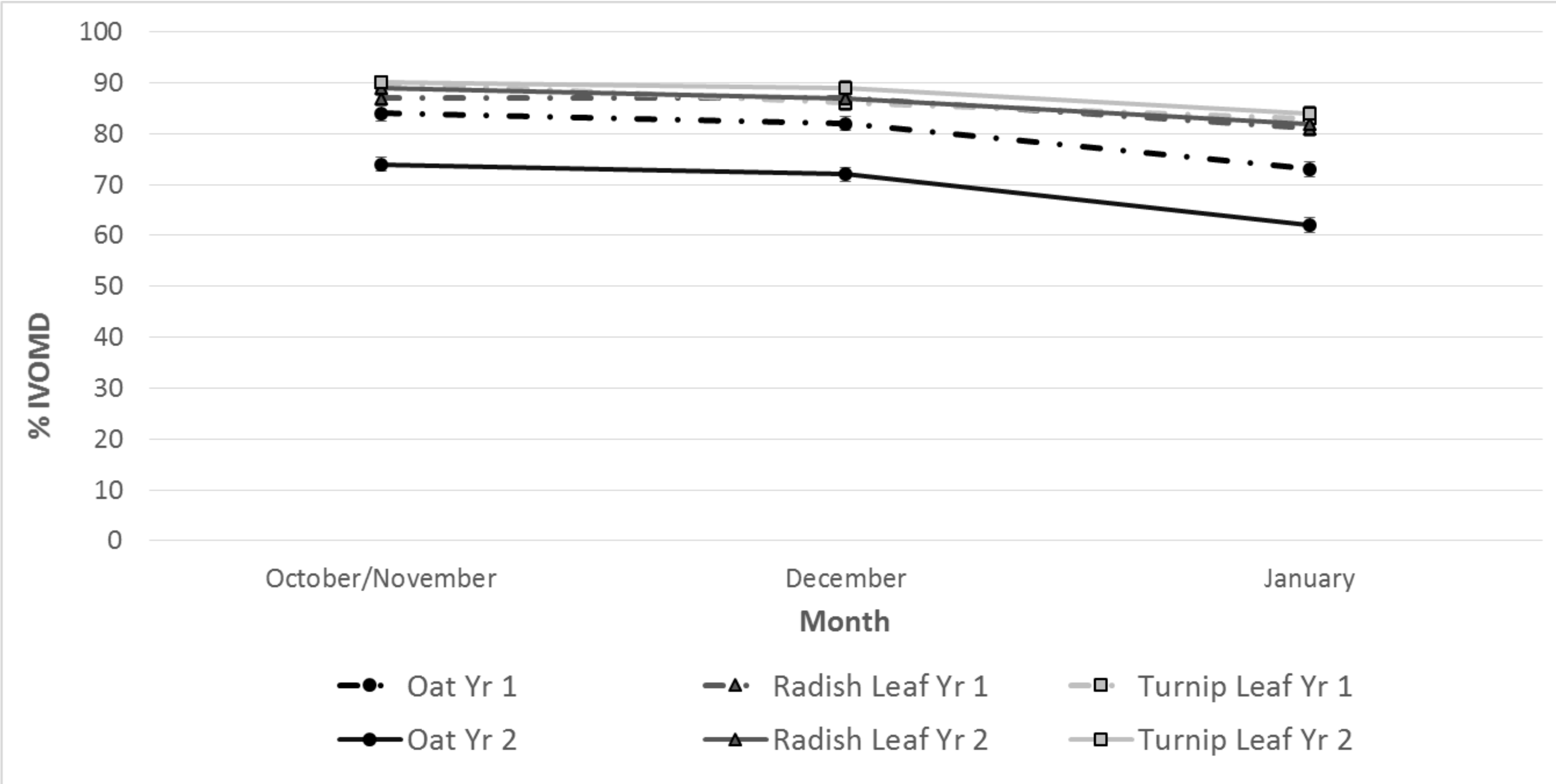
**IX. Percent acid detergent fiber (ADF) on a DM basis over time of individual forage component in oat-brassica mix for yr 1 and yr 2**



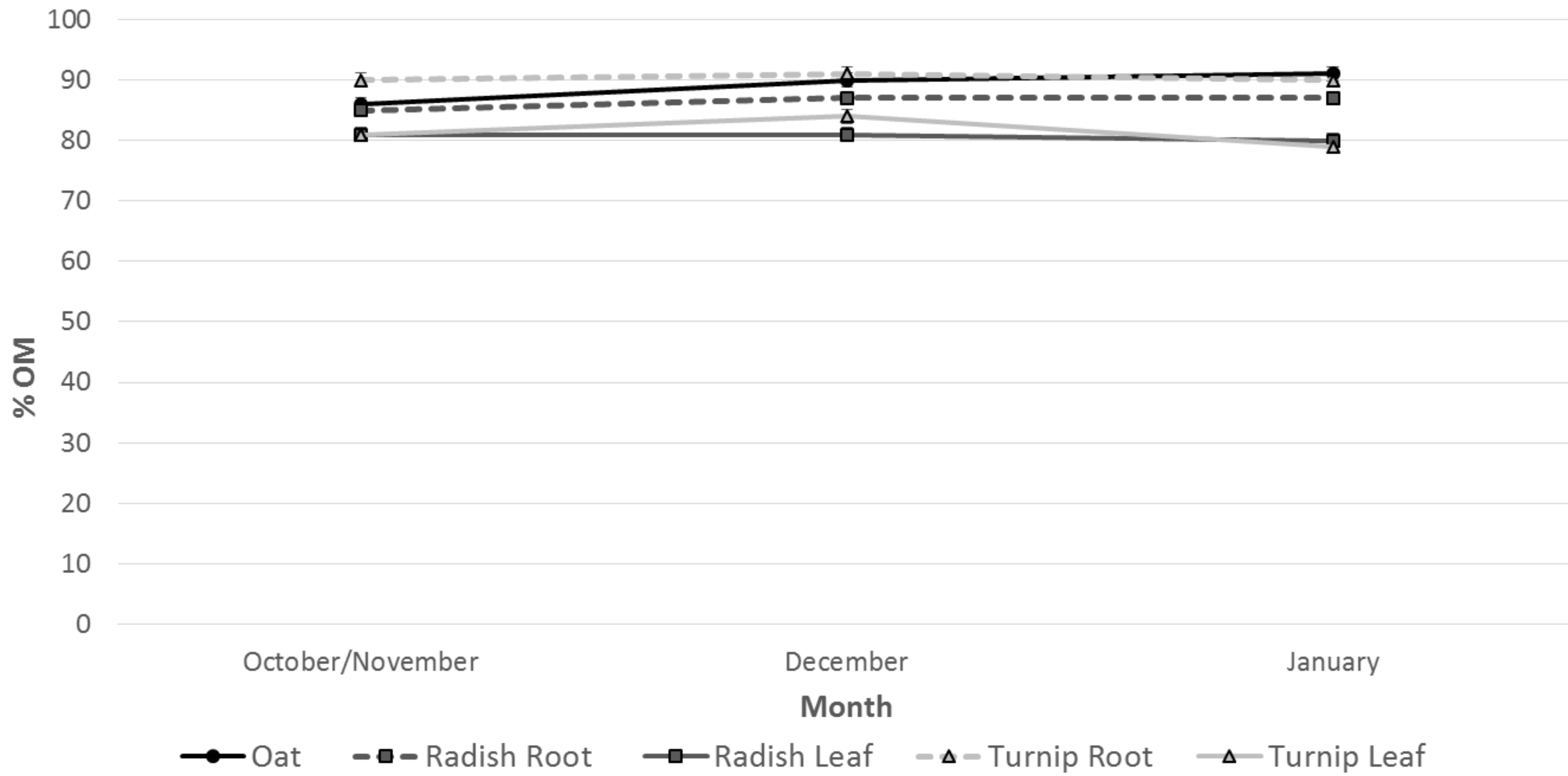
**X. Percent in-vitro dry matter digestibility (IVDMD) on a DM basis over time of individual forage component in oat-brassica mix for yr 1 and yr 2**



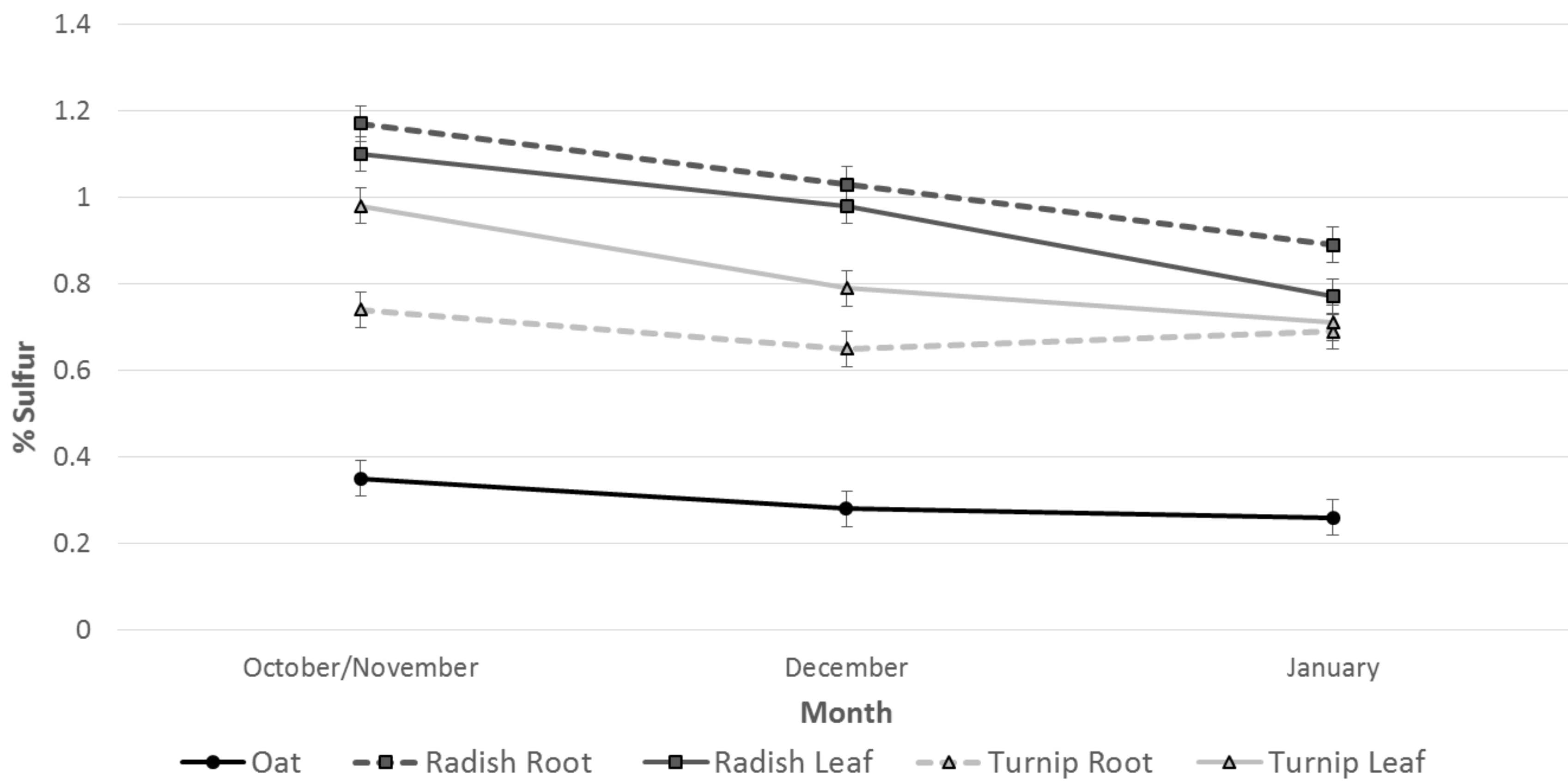
**XI. Percent in-vitro organic matter digestibility (IVOMD) on an OM basis over time of individual forage component in oat-brassica mix for yr 1 and yr 2**



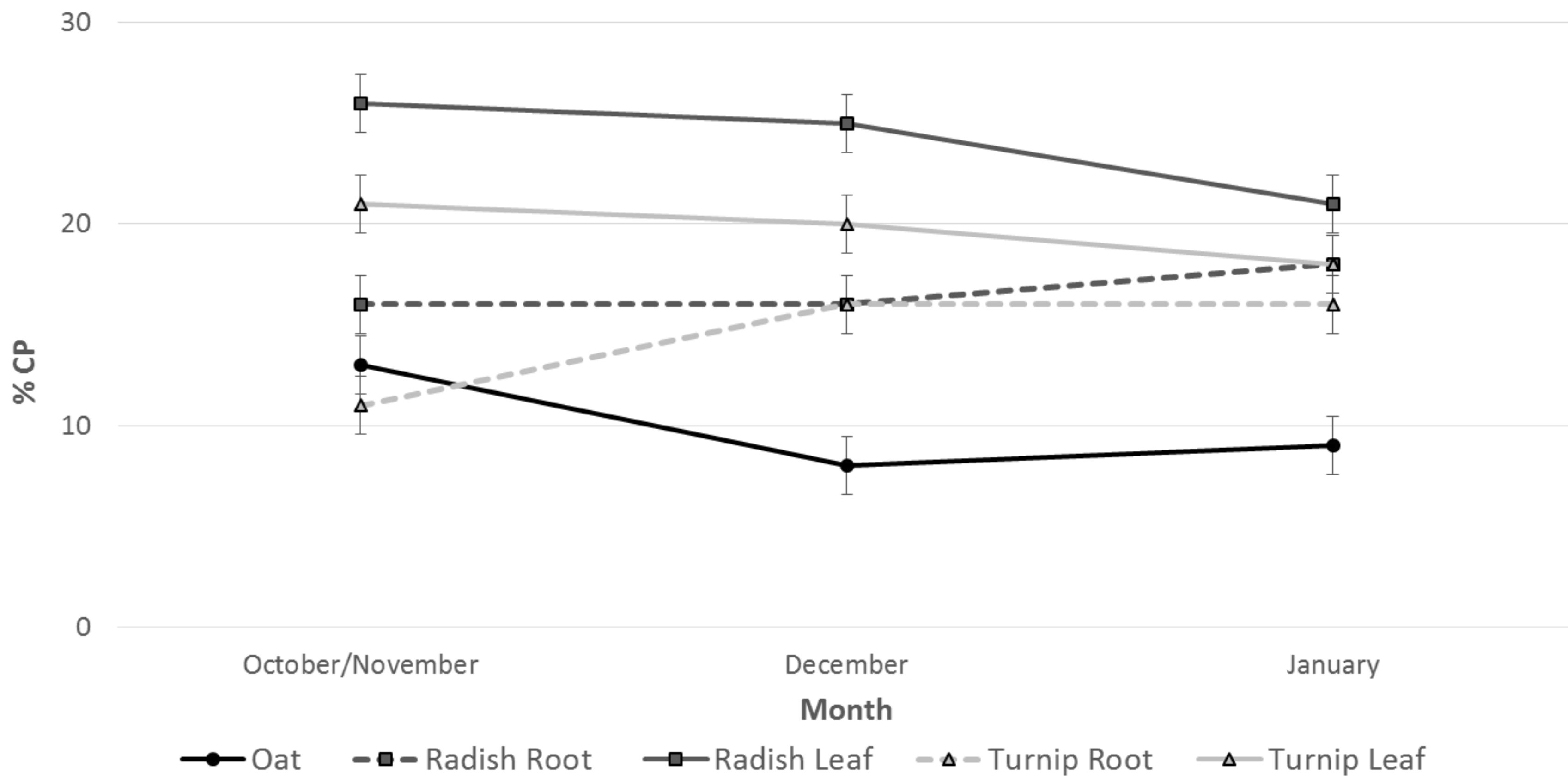
**XII. Percent organic matter (OM) on a DM basis over time of individual forage component in oat-brassica mix during yr 2**



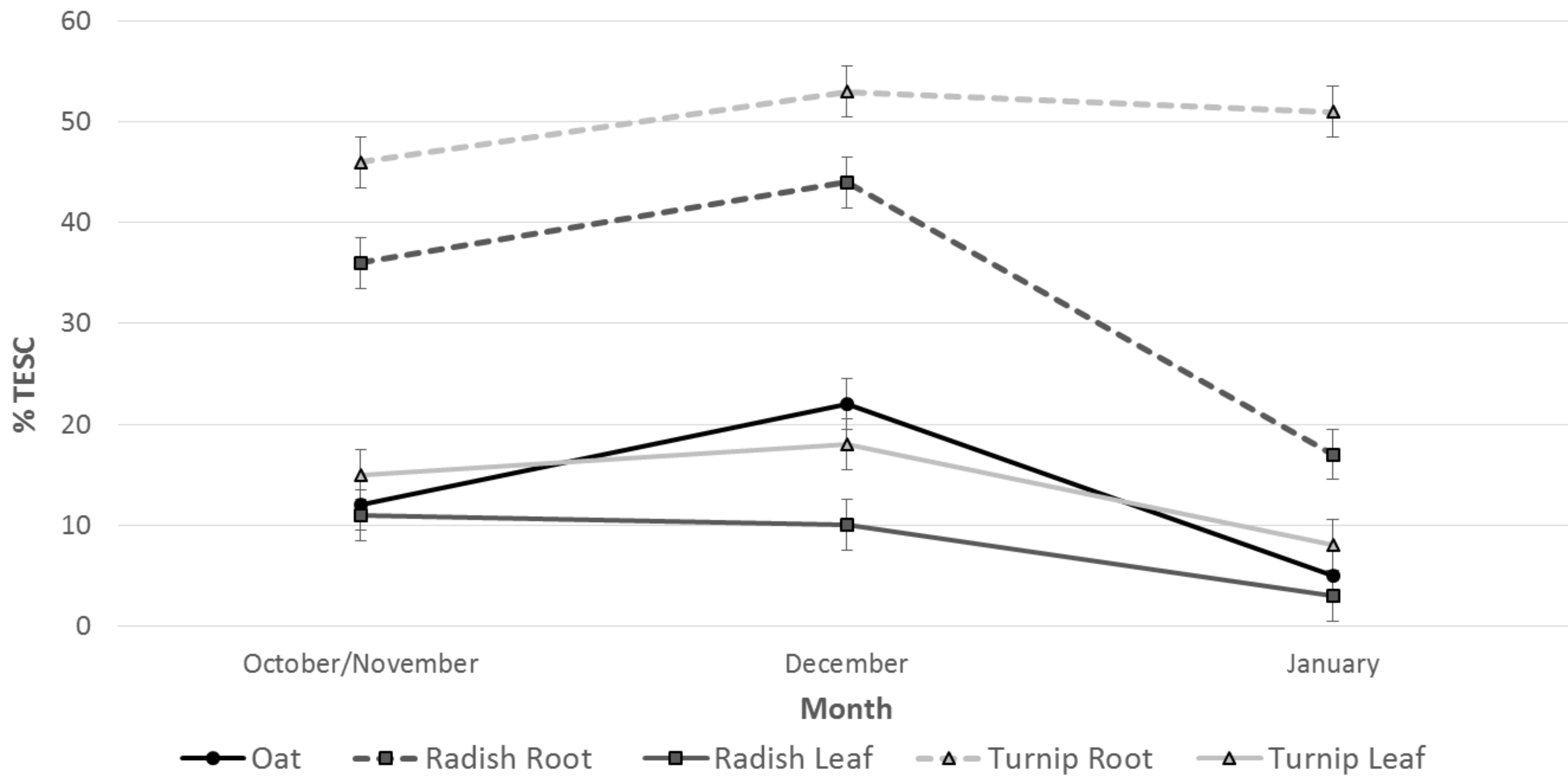
**XIII. Percent Sulfur on a DM basis over time of individual forage component in oat-brassica mix during yr 2**



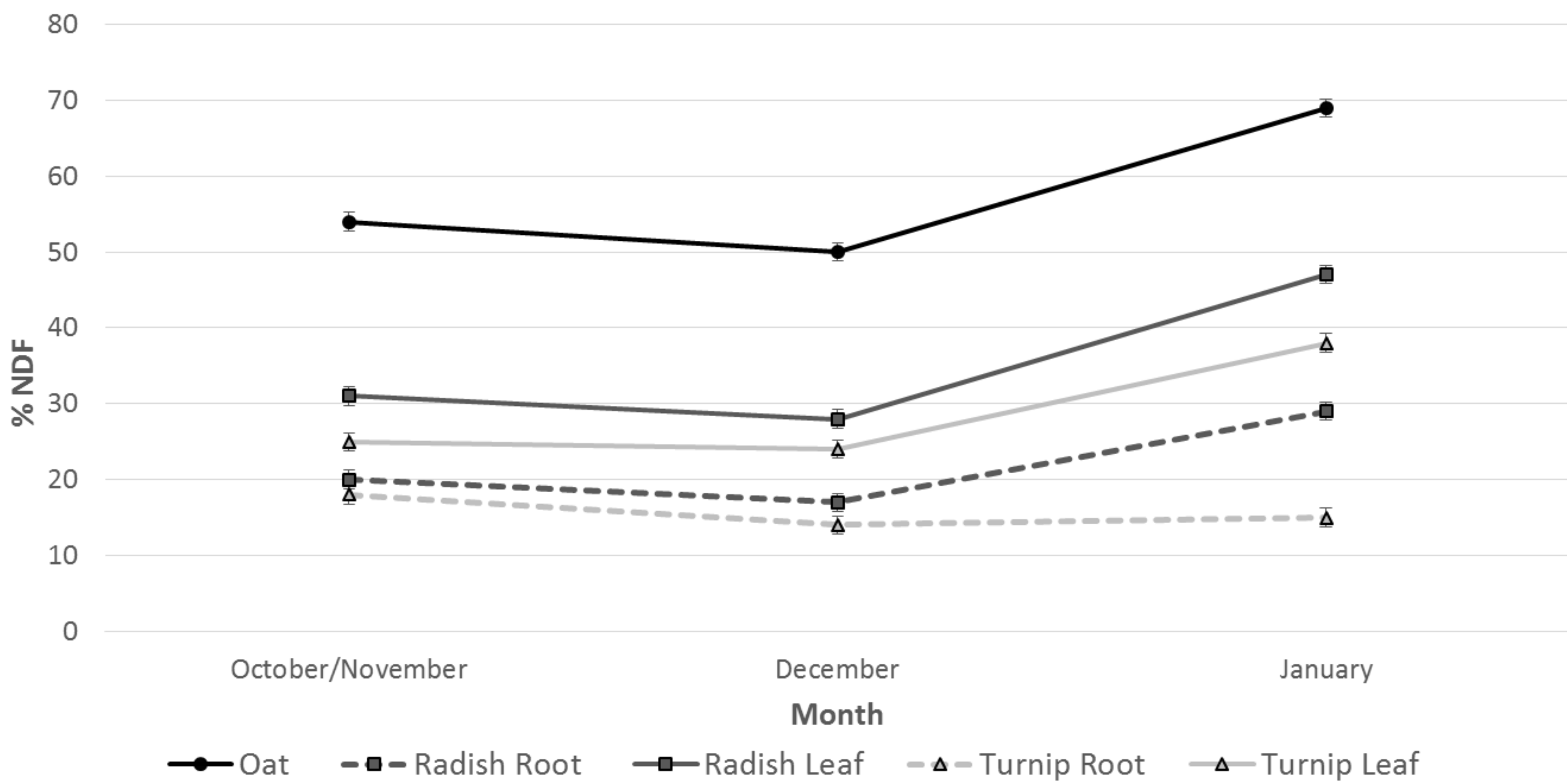
**XIV. Percent crude protein (CP) on a DM basis over time of individual forage component in oat-brassica mix during yr 2**



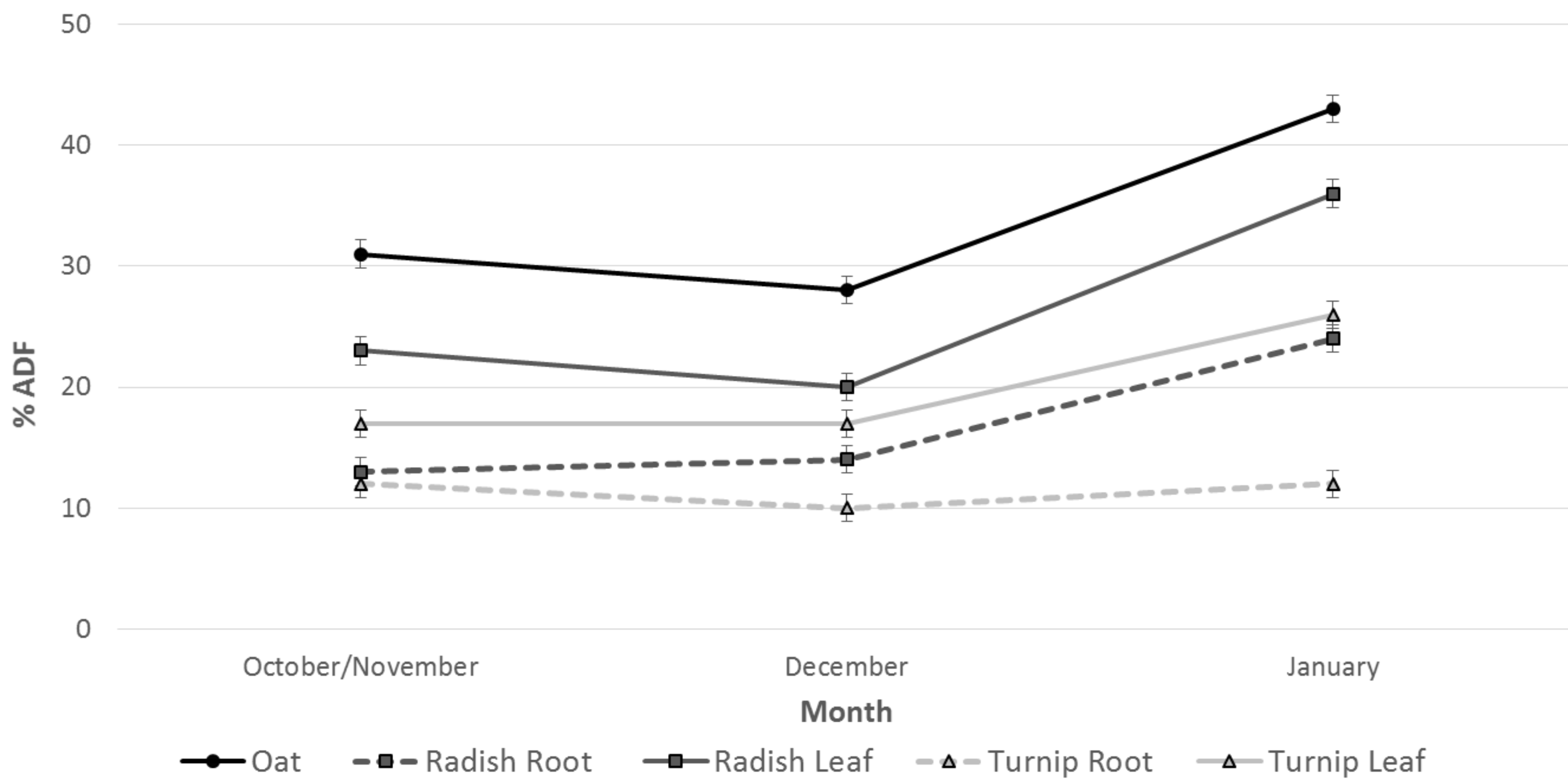
**XV. Percent total ethanol soluble carbohydrates (TESC) on a DM basis over time of individual forage component in oat-brassica mix during yr 2**



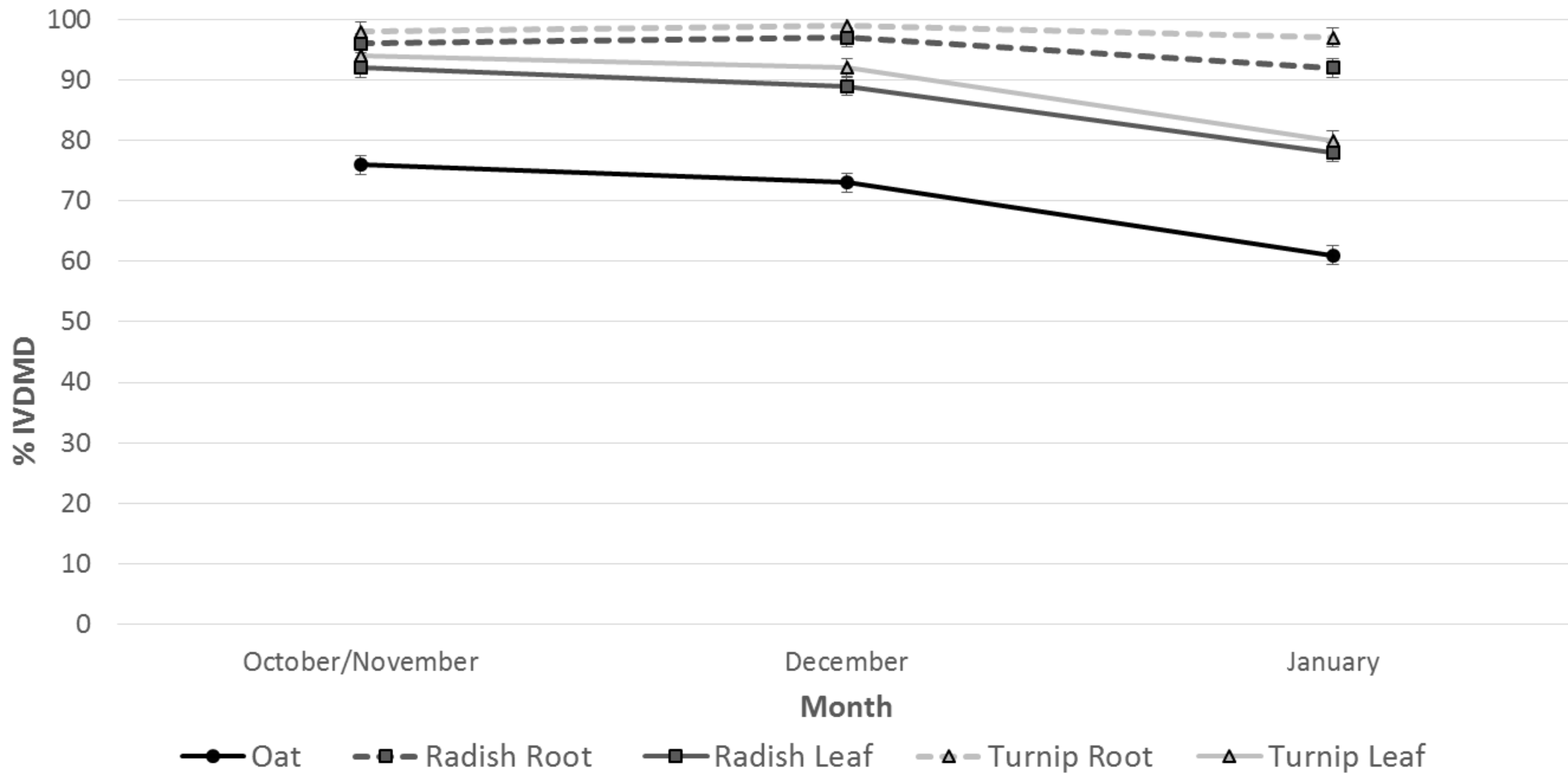
**XVI. Percent neutral detergent fiber (NDF) on a DM basis over time of individual forage component in oat-brassica mix during yr 2**



**XVII. Percent acid detergent fiber (ADF) on a DM basis over time of individual forage component in oat-brassica mix during yr 2**



**XVIII. Percent in-vitro dry matter digestibility (IVDMD) on a DM basis over time of individual forage component in oat-brassica mix during yr 2**



**XIX. Percent in-vitro organic matter digestibility (IVOMD) on a OM basis over time of individual forage component in oat-brassica mix during yr 2**