OBJECTIVES: The objective of this experiment was to determine the effects of strategic supplementation on yearling performance and effects on economic return.

MATERIALS AND METHODS:Predominantly Red Angus-crossbred steers and heifers (12–14 mo old; initial BW = 316 kg, SD = 8.6 kg) grazed crested wheatgrass at 4.3 ha/yearling for an average of 112 d in a 3-yr study. Treatments were (1) dried distillers grains (DDGS) supplemented at 1.59 kg/yearling per day fed 6 d/wk throughout the entire grazing season (full season, FS), (2) 1.59 kg/yearling per day supplemented for 6 d/wk only during the latter part of the grazing season (late season, LS), or (3) no supplement (control, CONT). Economic data from 2012 to 2021 were applied to experimental data to create potential yearling marketing scenarios and a partial budget analysis. Costs of both DDGS and live cattle were included. Pasture was the experimental unit (4 replicates in yr 1 and 2; 3 replicates in yr 3) in a randomized complete block design.

RESULTS AND DISCUSSION: There were no significant year × treatment interactions (P > 0.53) for performance. Supplement increased (P < 0.01) ADG 0.23 kg/d over CONT. Ending BW and ADG did not differ (P = 0.31) between FS and LS. There was a tendency for a treatment × year interaction (P = 0.08) for return to management. A significant increase (P < 0.01) in return to management over CONT was observed in yr 2 for FS and yr 2 and 3 for LS. Overall, FS returned $14.96 more and LS returned $32.21 more per yearling than CONT. Return from LS and FS was greater (P < 0.05) than CONT in all years except 2012, 2019, and 2021.

IMPLICATIONS AND APPLICATIONS: Strategically timed supplementation with DDGS as forage quality declined resulted in similar yearling performance as supplementing throughout the entire grazing season and increased economic return to management.

KEYWORDS: breakeven, crested wheatgrass, profitability, protein supplementation, stocker cattle

INTRODUCTION

In the United States, 70% of the calves are born between January and July, and only 30% are born between July and December (Peel, 2003). A common practice in the cattle industry is to grow spring-born calves on forage diets throughout the winter and summer before feedlot entry as long yearlings to increase cattle weights and to maintain a more constant supply of feeder cattle.

According to a National Stocker Survey (Farm Progress Companies, 2021) the top 4 performance measures for stocker cattle operations are profit/loss, shipping weight, ADG, and cost of gain. Providing supplementation to cattle grazing growing forage has been shown to increase gains on warm-season summer native range (Martinez-Pérez et al., 2013), Sandhills meadow (Griffin et al., 2012), bromegrass (Watson et al., 2015), and crested wheatgrass (Greenwell et al., 2018). Although stocker producers have indicated increased shipping weight and ADG as important performance metrics, summer supplementation is not a common practice in many regions, including Nebraska.

Because profit/loss and cost of gain were ranked in the top 4 measures (Farm Progress Companies, 2021), it is likely that stocker producers assume the added cost of supplementation (feed and labor) on growing forage would not be economical. In fact, McCollum and Horn (1990) reported supplementation to be one of the greatest economic drains on grazing cattle returns if not managed properly. Troyer et al. (2020) reported decreased gain during the...
latter half of the summer grazing season when the cool-season forage began to mature, suggesting that supplementation might be most beneficial later in the grazing season. Therefore, the hypothesis of this experiment was that strategically supplementing during the latter half of the summer would result in similar ending BW and ADG as calves supplemented all season long, while simultaneously reducing the amount of supplement fed and number of supplementation events (less labor), thereby improving the profitability of supplementation. Therefore, the objective of this experiment was to determine the effects of strategic supplementation timing on yearling cattle performance and effects on economic return using 10-yr livestock and supplement values.

### MATERIALS AND METHODS

#### Collection of Biological Data

All animal care and management procedures were approved by the University of Nebraska-Lincoln Institutional Animal Care and Use Committee (protocol no. 1964).

A 3-yr grazing experiment was conducted at the High Plains Agricultural Lab, near Sidney, Nebraska, from 2019 through 2021. Over the 3 yr, 312 total yearling cattle were sourced from the same producer. In year 1 a total of 114 steers (333 kg, SD 15 kg), in year 2 total 114 heifers (264 kg, SD 19 kg), and in year 3 total 84 steers (351 kg, SD 44 kg) were used. All yearlings were vaccinated in the autumn before arrival at the research facility in the spring and before being under the management of university personnel. Yearlings grazed on pastures containing primarily crested wheatgrass for an average of 112 d from late May to early September. However, the grazing length varied in each experimental year due to forage availability (Table 1).

Yearlings were weighed over 2 consecutive days at the beginning and end of the grazing period to determine an average beginning and ending body weight. The yearlings were blocked according to beginning body weights. Yearlings were assigned within weight block to a pasture and given a colored panel tag to represent that pasture group. Pasture was then assigned to 1 of 3 treatments: control (CONT), no supplement fed; full season (FS), 1.6 kg DM of dried distillers grains (DDGS) fed per yearling 6× weekly from May to September (FS); or late season (LS), 1.6 kg DM of DDGS fed per yearling 6× weekly from July to September (LS). The DDGS used for this experiment contained 34.1% CP, 15.9% ADF, 33.0% NDF, and 9.6% crude fat, with an assumed TDN of 108% (Loy et al., 2008; DM basis). The initial body weights and sex of the yearlings varied in each experimental year due to calf availability (Table 1).

In yr 1 and 2, there were 12 total grazing groups (n = 4 replicates per treatment), and yr 3 had 9 total grazing groups (n = 3 replicates per treatment). In years 1 and 2, there were 3 replicates for each treatment with 10 animals, and 1 replicate for each treatment with 8 animals. In year 3, there were 2 replicates for each treatment with 10 animals and 1 replicate for each treatment with 8 animals. Pastures containing 42.5 ha housed 10 animals, and pastures containing 34 ha housed 8 animals, to provide 4.3 ha per yearling (Table 1). Grazing replicates changed pastures every 2 wk to reduce potential variation due to pasture.

Over the 3 yr, LS received 54% of the amount of supplement of FS. Supplement was weighed into buckets and hand delivered Monday through Saturday into 3-m bunks, with yearlings having access to both sides of the bunk, near each pasture’s water source. Cattle had ad libitum

### Table 1. Description of animal type and supplementation strategies across 3 experimental years for yearlings grazing crested wheatgrass pastures

<table>
<thead>
<tr>
<th>Item</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>333 ± 15</td>
<td>264 ± 19</td>
<td>351 ± 44</td>
</tr>
<tr>
<td>Yearling sex</td>
<td>Steers</td>
<td>Heifers</td>
<td>Steers</td>
</tr>
<tr>
<td>Length of supplementation, d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONT</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FS</td>
<td>125</td>
<td>99</td>
<td>111</td>
</tr>
<tr>
<td>LS</td>
<td>70</td>
<td>55</td>
<td>56</td>
</tr>
<tr>
<td>Total supplementation, kg/yearling (DM basis)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CONT</td>
<td>170</td>
<td>135</td>
<td>151</td>
</tr>
<tr>
<td>FS</td>
<td>95</td>
<td>75</td>
<td>76</td>
</tr>
<tr>
<td>LS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Treatments across all experimental years were control (CONT), no supplement fed; full season (FS), 1.6 kg DM of dried distillers grains (DDGS) fed per yearling 6× weekly from May to September (FS); or late season (LS), 1.6 kg DM of DDGS fed per yearling 6× weekly from July to September (LS). The DDGS used for this experiment contained 34.1% CP, 15.9% ADF, 33.0% NDF, and 9.6% crude fat, with an assumed TDN of 108% (Loy et al., 2008; DM basis). The initial body weights and sex of the yearlings varied in each experimental year due to calf availability (Table 1).

2Weights are raw mean ± SD.
access to trace mineralized salt blocks that provided 2,400 
mg/kg Mn and Fe, 260 mg/kg Cu, 320 mg/kg Zn, 70 mg/
kg I, and 40 mg/kg Co. The water source was checked
daily.

Cattle were weighed in the morning for 2 consecutive
days at the beginning and the end of the experiment to
to determine average beginning and ending body weight.
The ADG was calculated from the beginning and ending
weights.

Forage samples were collected from 4 representative pas-
tures every 2 wk to monitor the change in available forage
quality. To collect the samples, four 0.25-m² frames were
collected from each pasture at representative points. Ev-
everything inside the frame was clipped to the ground and
kept for quality analysis. Samples from the northern 2
pastures were composited together, and samples from the
southern 2 pastures were composited together. Following
collection, forage samples were dried in a 60°C oven and
then ground through a 1.0-mm screen in a Wiley mill,
(Model No. 3, Thomas Scientific, Swedesboro, NJ). Sam-
ples were placed in a forced-air oven for 24 h at 105°C
to determine DM. Samples were then placed in a muffle
furnace for 6 h at 600°C to determine OM (AOAC, 1999).
Samples were analyzed for in vitro DM disappearance in
2 runs using the Tilley and Terry (1963) method modi-
ified by the inclusion of 1 g of urea/mL of buffer (Weiss,
1994). A set of forage standards with established in vivo
values were included in each run to develop regression
equations that allowed for the comparison between runs
(Geisert, 2007). Samples were replicated in triplicate. The
process was repeated twice (2 runs were conducted) and
averaged. Samples were then filtered using Whatman 541
paper. Crude protein was measured using a combustion N
analyzer (AOAC, 1999, method 990.03; TruSpec N Deter-
minator, Leco Corporation, St. Joseph, MI).

**Collection of Meteorological Data**

Daily temperature and precipitation information was
obtained from the MesoNet station (https://mesonet.unl.
.edu/) located at the High Plains Agricultural Lab, near
Sidney, Nebraska. Daily high and low temperatures were
collected and averaged to create a single average daily
temperature.

The meteorological data were divided into 3 time peri-
ods for evaluation. Data from March 1 through May 15
were considered as the pre-grazing period. Data from May
16 to July 15 were considered as the first half of the graz-
ing season conditions, when only the yearlings on the FS
treatment were receiving supplement. Data from July 16
to September 30 were considered as the second half of
the grazing season conditions, when the yearlings on the LS
treatment were also receiving supplement.

**Developing Economic Data**

Average weekly live cattle prices for Nebraska were
obtained using Livestock Marketing Information Center
Weekly & Monthly Combined Nebraska Auction Cattle
Prices (LMIC, 2022) on 23-kg (50-lb) weight increments
for the months of May, August, and September from 2012
through 2021. Weekly prices were combined to determine
average monthly prices for live cattle at varying weight
classes for each year of the previous decade. Additionally,
average weekly DDGS prices for Nebraska were obtained
from USDA for the months of May through September
from 2012 through 2021 (AMS-USDA, 2021). Market
prices were combined to determine an average grazing
season (May–Sept) price for DDGS for each year of the
previous decade. “Experimental year” refers to the 3 yr
during which biological data were collected, whereas “eco-
nomic year” refers to the 10 yr of historical market data

**Application of Biological Data to Economic Data**

A partial budgeting approach was taken for the applica-
tion of recorded biological data (cattle performance) to
the economic data (market prices for 2012–2021). The
calculated price of DDGS in each economic year was mul-
tiplied by the amount of supplement fed to an animal
in FS or LS during each year of the experiment. These
values simulated the potential cost of supplementation for
each treatment in the given economic climate. The cost of
labor to provide supplementation to the animals was not
accounted for, due to the wide variety of potential labor
costs for each individual operator; thus the return to man-
agement was evaluated. Sizes of herds and travel distance
to deliver supplement can have large effects on the labor
costs of supplementation. It should be noted that the stra-
tegically supplemented calves in this experiment would
have had reduced labor costs compared with season-long
supplementation due to the reduction in supplementation
events.

The potential change in yearling value was calculated us-
ing the 3 yr of biological weight information and applying
it to the 10 yr of collected cattle market information. Al-
though the experiment was only conducted for 3 yr (2019,
2020, and 2021), variation of the cattle market would be
independent of the observed cattle performance. The aver-
age beginning weight from each replicate within each bio-
ological year was applied to May cattle market prices from
2012 through 2021 to create simulated beginning values
for those years. This value describes the potential cost
to buy those animals in May or the opportunity cost of
retaining ownership of those animals. The average ending
weight from each replicate within each biological year was
applied to August (yr 2) or September (yr 1 and 3) cattle
market prices from 2012 through 2021 to create simulated
ending value for those years. This value describes the po-
tential revenue of a producer who sold yearling cattle in
August or September in each year of the previous decade.
The calculated beginning value for each group within
each experimental year was subtracted from the calcu-
lated ending value to determine the change in value of

that animal. This change in value is described as margin. The calculated cost of supplement for FS and LS in each year was then subtracted from the margin to determine the gross margin for each treatment scenario across 10 economic years. The gross margin for the control treatment was then subtracted from the gross margins for the FS and LS treatments to yield the difference in return. Thus, CONT was set equal to zero and considered as the baseline for comparison.

Applying the 3 yr of collected biological data to the 10 yr of historical economic data allowed for evaluation of potential differences for each treatment among a variety of marketing conditions. Cattle markets typically follow a 10-yr cycle of variation. By simulating potential marketing scenarios in this manner, the inherent variability of market prices for both DDGS and live cattle was taken into account.

Statistical Analysis

All data were analyzed as a randomized complete block design with animal group considered the experimental unit, with initial BW as the blocking factor. Yearling performance data were analyzed using the Mixed procedure of SAS 9.4 (SAS Institute Inc., Cary, NC). The model for yearling performance (beginning weight, ending weight, and ADG) included the fixed effects of treatment, experimental year, block, and the treatment × experimental year interaction. Interactions with $P > 0.20$ were removed from the model. Significance was considered when $P ≤ 0.05$.

For economic return data, the CONT was set to zero and the return relative to the control was evaluated. The data were analyzed using the GLIMMIX procedure of SAS. The model included the fixed effects of treatment, experimental year, economic year, and their respective interactions. A Tukey’s adjustment was applied. Block was included as a random effect. Interactions with $P > 0.20$ were removed from the model. When the F-test was significant, a t-test of the 95% confidence interval for LS and FS was used to determine differences from CONT (i.e., zero) and the DIFF option was used to compare FS to LS.

RESULTS AND DISCUSSION

Biological Data

No significant year × treatment interactions were found ($P > 0.53$). As designed, there were no differences ($P > 0.98$) among treatments in initial BW of the yearlings (Table 2). Ending BW was greater for FS and LS (419 kg and 416 kg, respectively; $P < 0.05$) than for CONT (396 kg). Additionally, BS and LS were not different ($P = 0.71$). Similarly, ADG was greater for FS and LS (0.93 kg/d and 0.88 kg/d; $P < 0.01$) than for CONT (0.68 kg/d). Average daily gain was not different for FS and LS ($P = 0.31$). These results agree with those reported by Griffin et al. (2012) in a meta-analysis of 12 studies supplementing summer-grazing yearlings with DDGS. Those authors reported a linear increase in ADG as DDGS was supplemented from 0 to 1.2% BW (DM basis), as well as a quadratic response in ending BW with peak ending BW at 0.8% and 1.0% BW supplementation. Greenwell et al. (2018) also reported increased ADG and ending BW over a non-supplemented control when yearlings grazing crested wheatgrass in the summer were supplemented with a corn and distillers solubles blend or field peas. Martinez-Pérez et al. (2013) also reported a linear increase in ADG and a quadratic increase in ending BW when yearling cattle grazing warm-season grasses in the summer were supplemented with DDGS up to 0.6% BW (DM basis). However, when supplementing growing calves grazing lush wheat pasture in the winter, Buttrey et al. (2012) reported no difference in ADG between non-supplemented cattle and those receiving 0.5% BW dry-rolled corn, but did report an increase in ADG over both the control and dry-rolled-corn treatment when DDGS was fed at 0.5% BW.

As previously stated, ending BW and ADG were not different ($P = 0.71$ and $P = 0.31$, respectively) for FS and LS (Table 2), even though FS was supplemented 1.4 kg/d DDGS for an average of 112 d and LS an average of 60 d across all 3 yr (Table 1). The majority of precipitation (Figure 1) occurred during the pre-grazing (March 1–May 15) and early-grazing (May 16–July 15) periods when temperatures (Figure 2) were cooler and crested wheatgrass was actively growing. Crude protein and in vitro DM disappearance declined over the grazing season (Table 3) as temperature increased, rainfall decreased, and the forage matured, likely contributing to the supplement response in the latter part of the grazing season (July–September). Past research has reported a similar pattern of lower forage quality in July (Pesta et al., 2012; Titlow et al., 2014), as optimal growing conditions decline and the plants move out of the vegetative phase and enter the reproductive phase.

The yearling cattle were supplemented with a fixed amount of DDGS regardless of yearling BW (1.4 kg/d, DM basis), resulting in a supplementation rate of 0.40% down to 0.30% of BW as yearling BW increased. Watson et al. (2015) also reported no difference in ending BW and ADG when DDGS was supplemented either all season long or starting after the first 56 d of grazing smooth brome-grass. However, in that study, the supplement was supplied at 0.5% BW (DM basis) and therefore increased as the cattle grew. As a result, the delayed supplementation treatment only resulted in feeding 20% less supplement than the season-long treatment. In the current study, LS was supplemented an average of 54% of FS, or 46% less than FS (Table 1).

Economic Analysis

There was a tendency ($P = 0.08$) for a year × treatment interaction for gross margin ($/yearling; Figure 3). Within year, FS did not differ ($P = 0.68$) from CONT in yr 1, tended to be greater ($P = 0.11$) in yr 2, and was greater
Within year, LS tended (P = 0.10) to have greater gross margin than CONT in yr 1 and had greater (P < 0.01) gross margin in yr 2 and yr 3. Within year, FS had less (P < 0.01) gross margin than LS in yr 1 and yr 2, but was not different (P = 0.51) from LS in yr 3. The analysis of average gross margin across treatments indicated that FS yearlings returned about $15 per yearling more than CONT yearlings, whereas LS yearlings returned about $32 per yearling more than CONT yearlings.

Greenwell et al. (2018) also reported a greater economic return from supplementing a blend of dry rolled corn and distillers solubles than non-supplemented summer-grazing yearling cattle.

The main effects of treatment, experimental year, and economic year were all significant (P > 0.01). The average gross margin of the 2 supplemented treatments is reported within economic year (2012–2021) in Figure 4. The average gross margin of FS and LS compared with CONT was significantly different (P < 0.05) in 7 of the 10 economic years, but not different (P > 0.24) from CONT in 2012, 2019, and 2021. The increase in gross margin for the FS treatment ranged from −$14 (2021) to $30 (2017) per yearling. The increase in gross margin for the LS treatment ranged from $6 (2021) to $50 (2015) per yearling. Conversely, Gillespie-Lewis et al. (2016) reported no economic benefit to summer supplementation when spayed heifers were overwintered with supplementation, supplemented on summer pasture, and finished in the feedlot before being sold. This indicates that point of sale can also influence the decision to supplement grazing cattle.

Value of gain (VOG) for an animal is defined as the change in value of the animal (margin) divided by the gain in weight. Comparing the cost of DDGS supplementation to gain an additional kilogram of BW to the VOG of LS and FS (supplemented treatments) provided insight to the observed differences in margin among economic years (Figure 5). The reduction in return observed in 2012 for the supplemented treatments was due to a low VOG relative to a higher cost of DDGS. Greenwell et al. (2018) also reported that supplementing grazing cattle with field peas returned less economic value than the non-supplemented controls because a salvage value for the field peas had not been set and a human consumption market price was used in the calculations. This indicates that the cost of supplementation should be carefully evaluated relative to the projected change in value per head. In 2015 and 2016, the VOG was again relatively low but was greater for the supplemented treatments with heavier yearlings than the CONT, resulting in the gross margin remaining greater for the supplemented treatments. In 2019, a decrease in the VOG and no difference in VOG between the supplemented and CONT treatments resulted in the gross margin not being different among treatments (although still numerically positive). The reduction in gross margin observed in 2021 was due to the VOG for CONT being greater than the VOG for the supplemented treatments.

| Table 2. Average performance across 3 experimental years for each treatment for yearlings grazing crested wheatgrass pastures |
|-----------------|---------|-------|--------|-------|
|                 | CONT    | FS    | LS     | SEM²  |
| Beginning BW, kg| 318     | 315   | 317    | 7.9   |
| Ending BW, kg   | 396b    | 419a  | 416a   | 6.7   |
| ADG, kg/d       | 0.68b   | 0.93a | 0.88a  | 0.03  |

a Means within a row with different superscripts differ (P < 0.05). Year × Treatment P = 0.53.

b Treatments across all experimental years were control (CONT), no supplement fed; full season (FS), 1.6 kg DM of dried distillers grains (DDGS) fed per yearling 6 d/wk throughout the entire grazing season; and late season (LS), 1.6 kg DM of DDGS fed per yearling 6 d/wk only during the latter half of the grazing season.

SEM reported as the largest value of the 3 yr.
because of a large price slide in 2021 associated with the additional 20 kg of gain achieved in the supplemented treatments (Table 2). The price slide is the tendency for the market price for cattle to decline as the animal’s weight increases. The average price slide for a calf in the 454- to 476-kg weight class, versus the 431- to 454-kg weight class, was 2% for the economic years 2012 to 2021. However, in 2021, the same price slide (decline) was 5.5%. The potential implications of the price slide should be added to the costs associated with supplementation. In general, value of the additional weight gained must exceed the cost of supplementation plus the negative effects of any price slide, for the supplementation strategy to work economically.

These data would also indicate that high DDGS cost coupled with low cattle market prices can reduce the benefit of supplementation. Additionally, delivery costs of supplement will affect the potential for return and needs to be considered. The breakeven cost of DDGS was also calculated (Figure 6) across the 10 yr of economic market data. The average cost of DDGS during the grazing season...
was $162/909 kg (1 US ton) and ranged from $105/909 kg to $272/909 kg. Breakeven prices of DDGS for LS averaged $530/909 kg and ranged from $268 to $822/909 kg. Breakeven prices of DDGS for FS averaged $250/909 kg and ranged from $123 to $343/909 kg. Labor was not considered in the main partial budget analysis of this experiment, due to the high variability in labor costs from producer to producer. However, when an estimated $0.30/yearling daily labor cost was added to LS, breakeven price of DDGS decreased to $345/909 kg but remained above the cost of DDGS for all 10 economic years except 2021. When a $0.30/yearling daily labor cost was added to FS, the breakeven price of DDGS decreased to $50/909 kg, due to the increased days of supplementation and fell below the cost of DDGS for all 10 economic years.

**APPLICATIONS**

Supplementing DDGS to yearling cattle grazing cool-season perennial pasture in the summer improved gains over non-supplemented yearlings. Providing supplementation during the latter half of the grazing season resulted in gains similar to those of cattle supplemented the entire grazing season, resulting in more economic return compared with cattle supplemented all season long or not supplemented at all. On average, for each 3 kg of DDGS supplement provided late in the summer season, yearlings gained an additional kilogram of BW, when fed at 1.6 kg DM/feeding, 6 d/wk. When the 3 years of biological data were evaluated over 10 yr of economic data, supplementing DDGS to yearling cattle grazing cool-season forages in the summer had a significantly greater return 7 out of 10 economic years.
years compared with not supplementing. Supplementing yearling cattle with DDGS the latter half of the grazing season and including $0.30/d labor, resulted in a break-even price for DDGS greater than the actual DDGS price in every year except 2021, when DDGS price was affected by drought and other economic conditions.

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LITERATURE CITED


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