Effect of corn silage inclusion level and steroidal implant type on growth performance, dietary net energy utilization, beef production per acre and apparent total tract digestibility in feedlot finishing steers.

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Objective

The experimental objective was to determine the influence corn silage inclusion level and terminal implant type have on animal performance, carcass traits, and beef production per acre of cropland in finishing steers harvested at a common fatness endpoint.

Study Description

Maine-Anjou × Angus beef steers (n = 156 steers; initial BW 807 ± 81.9 lbs) were used in a 2 × 2 factorial arrangement finishing experiment at the Ruminant Nutrition Center in Brookings, SD. Steers were weighed on 2 consecutive days and assigned into 5 weight blocks. Dietary treatments consisted (DM basis) of 1) 15% (CS15) or 2) 30% corn silage (CS30). Implant treatments consisted of 1) Coated implant, 200 mg trenbolone acetate (TBA), 28 mg estradiol benzoate (EB) (Synovex ONE Feedlot, ONE) or 2) Non-coated implant, 200 mg TBA, 28 mg EB (Synovex PLUS; PLUS).

Take Home Points

Feeding CS15 resulted in greater carcass-adjusted growth performance and HCW. No differences in beef produced per acre of crop land was observed, meaning producers can feed greater inclusions of corn silage to finishing cattle without impacting carcass quality or beef production. Implanting cattle with a coated implant had no detrimental effect on growth performance or carcass traits, but increased marbling scores.

Introduction

Corn silage is a prevalent feed ingredient used by beef producers in the Midwest region of the United States. Corn silage is a readily available source of energy and fiber for cattle producers and can be used to market home-raised feedstuffs through cattle. Long held paradigms insist that the most effective use of corn silage is in growing cattle diets, and in finishing cattle, that corn silage inclusion be limited to the amount that is necessary to provide sufficient fiber to maintain ruminal health. Many integrated crop-livestock systems may desire to increase the utilization of corn silage for a variety of reasons such as undesirable weather conditions and workload demands at harvest, and demand for field corn depending upon geographical location. Increased inclusion rates of corn silage in finishing diets may be economically beneficial, primarily associated with the level of integration between crops and livestock. The majority of studies evaluating corn silage inclusion measure efficiency on an individual animal basis, few have evaluated corn silage inclusion in terms of the amount of beef that can be produced from a fixed land basis, which is highly important in an integrated crop-livestock system.

Steroidal hormones with anabolic activity have been safely used in U.S. beef production since 1956. Anabolic implants containing trenbolone acetate (TBA) and estradiol-17β (E2) have been approved for use in confined finishing cattle by the U.S. Food and Drug Administration (FDA) for over 26 y. Implants increase frame size and delay fattening. In the last 13 y, the FDA has approved four TBA + E2 coated implants that extend hormonal release to 200 d post-implantation for use in feedlot cattle.

The experimental objective was to determine the influence corn silage inclusion level and terminal implant type have on animal performance, carcass traits, and beef production per acre of cropland in finishing steers harvested at a common fatness endpoint.

Experimental Procedures

All procedures involving the use of animals in this experiment were approved by the South Dakota State University Institutional Animal Care and Use Committee (Approval #19-026E).

Animal Management, Dietary and Implant Treatments

Maine-Anjou × Angus crossbred beef steers (n = 156 steers; initial BW 807 ± 81.9 lbs) were used in a 132 finishing study that was conducted at the Ruminant Nutrition Center (RNC) in Brookings, SD. There were 7 to 8 steers assigned to each of the 20 pens used in this experiment. The steers used in this experiment were procured in the fall of 2019 and were used in an unrelated receiving and backgrounding phase experiment. The steers were selected for uniformity from a pool of 199 steers. All 199 steers were weighed on d -1 and this BW was used for allotment purposes. The final pool of 156 steers were stratified by weight into 5 weight blocks. Once assigned to BW blocks, steers were assigned by random sequence to diet; steers were then sorted by BW within each block and diet and assigned by random sequence to implant treatment.

The BW measures collected on d -1 and 1 were shrunk 4% to account for digestive tract fill, and then averaged to determine the initial on-test BW. Steers received their respective implant treatment on study d 1. Implants used were: 1) Synovex PLUS (non-coated implant; 200 mg TBA and ~20 mg E_2; PLUS) and 2) Synovex ONE Feedlot (coated implant; 200 mg TBA and ~20 mg E_2; ONE-F), implant retention was evaluated on d 28 by a single trained evaluator, abnormal implant rate was 12.2%: abnormalities included abscessed (1 steer), abscessed out (1 steer), hard (1 steer), knot (1 steer), partial (3 steers), and soft inflammation (12 steers). Severe abnormalities including abscessed and abscessed out rate was only 1.3%. The steer identified as abscessed out was re-administered the treatment implant during the interim weighing procedure on d 28. The dietary treatments included (DM basis): 1) 15% corn silage (15) or 2) 30% corn silage (30) where corn silage displaced corn grain in the diet. Thus, treatments were arranged in a 2 × 2 factorial arrangement consisting of: 1) PLUS/15, 2) PLUS/30, 3) ONE-F/15, and 4) ONE-F/30.

Test diets were fed beginning on study d 1 (Table 1) and fed at 2% of BW (DM basis). Intake was by prescription for the transition to *ad libitum* feeding, which required approximately 21 d (varying among pens). All steers were fed diets twice daily in equal portions. Feed deliveries were managed so that there was minimal day-to-day variation in the quantity of feed delivered, and such that only a small portion of feed remained in the bunks each morning. Feed ingredients were sampled weekly for determination of DM, CP, NDF, ADF, and ash content (the NDF and ADF of DRC and HMC was assumed at 9 and 3%, respectively). Targeted inclusion of corn silage in the test diets was achieved; composition of the test diets (Table 1) was reconstructed from actual feed batching records and weekly ingredient composition along with tabular energy values (Preston, 2016); intake records were compiled at 7 d intervals. Steers that were removed from the study or that died during the study were assumed to have consumed feed equal to the pen mean DMI up to the point of removal or death. A total of seven steers were removed during the course of the study due to health reasons not related to treatment. One steer was from PLUS/15 and was removed due to irresolvable diphtheria, two steers were removed from ONE-F/15 due to irresolvable pneumonia (1 steer) and heart failure (1 steer), respectively, three steers were removed from PLUS/30 due to pneumonia (1 steer), poor weight gain (1 steer), and heart failure (1 steer), respectively, one steer was removed from ONE-F/30 due to irresolvable bloat. All pen mean BW data were recalculated after these individuals were deleted from the data set.

Growth Performance Calculations

Individual steer BW was recorded for each animal at d -1, 1, 28, 56, 84, 112, and on d 132 the morning prior to shipment for the calculation of live growth performance. Body weights were measured prior to the morning feeding; a 4% pencil shrink was applied to initial (average of d -1 and 1) and final BW, carcass-adjusted performance was calculated from HCW/0.63.

NE Calculations

Observed dietary NE was calculated using live shrunk-basis growth performance, and from daily energy gain (EG; Mcal/d): EG = $ADG^{1.097}$ $0.0557W^{0.75}$, where W is the mean equivalent shrunk BW [kg; (NRC, 1996)]. Using final BW at 28% empty body fat (EBF) as mature final BW (NRC, 1996; Guiroy et al., 2001). Maintenance energy (EM) was calculated by the equation: EM = 0.077(median feeding $BW^{0.75}$). Dry matter intake is related to energy requirements and dietary NEm according to the following equation: DMI = EG/(0.877NEm − 0.41), and can be resolved for estimation of dietary NEm by means of the quadratic formula $x = (-b - \sqrt{(b^2 - 4ac)})/2c$, where a = −0.41EM, b = 0.877EM + 0.41DMI + EG, and c = −0.877DMI (Zinn and Shen, 1998). Dietary NEg was derived from NEm by the following equation: NEg = 0.877NEm − 0.41 (Zinn, 1987).

Beef Production per acre calculations

Beef production per acre of crop production was calculated from actual intake of corn silage and corn (DRC and HMC) for each pen. These calculations were done using the weekly diet compositions and DMI records. Corn silage yield was assumed to be (as-is basis) 22.5 tons/acre. Corn yield (bu/acre) was estimated from corn silage yield using the following equation: corn silage yield (as-is basis; tons/acre) × 8. Thus, the assumed field corn yield (85% DM) was 180 bu/acre. To estimate the HMC corn yield, field corn was corrected to DM basis (assuming 85% DM for field corn) and divided by the actual DM of the HMC fed (69.89% DM for HMC). Cropland required was the sum of pounds consumed/yield for corn and corn silage. Beef production per acre was then calculated as: (Final BW-shrunk initial BW)/acres (on both a live-shrunk and carcass-adjusted final BW basis).

Carcass trait calculations

Cattle were shipped when they were visually appraised to have approximately 0.40 in of rib fat (RF). Cattle were shipped on June 12, 2020 and harvested the following day at Iowa Premium Beef in Tama, IA. Steers were co-mingled at the time of shipping and remained as such until 0700h the morning following shipping. Individual steer identity was tracked through the harvest facility. Hot carcass weight was recorded at the hot scale during the tag transfer procedure. Carcass traits such as rib eye area (REA), RF, and USDA marbling scores were obtained from trained personnel at the packing plant. Dressing percentage (DP) was calculated as: HCW/(Final BW × 0.96). Yield grade was determined using the USDA regression equation (USDA, 1997). Estimated empty body fat percentage was calculated using carcass traits and BW at 28% EBF was estimated using equations described previously (Guiroy et al., 2001; Guiroy et al., 2002). Estimated proportion of closely trimmed boneless retail cuts from carcass round, loin, rib, and chuck (Retail Yield) was also calculated from carcass traits (Murphey et al., 1960).

Statistical analysis

Growth performance was calculated on a deads and removals- excluded basis. Growth performance and carcass traits were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. Categorical data (i.e. USDA Quality grade and Yield grade) were analyzed as binomial proportions using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc.). For all analyses, the model included the fixed effects of steroidal implant, corn silage inclusion level, and their interaction; block was considered a random effect. Least squares means were generated using the LSMEANS statement of SAS. Data means were separated and denoted to be different using the pairwise comparisons

PDIFF and LINES option of SAS when a significant preliminary F-test was detected. An α of 0.05 determined significance and tendencies are discussed from 0.05 to 0.10.

Results and Discussion

Interim and cumulative un-shrunk steer growth performance is presented in Table 2. Cumulative shrunk (4% shrink to account for digestive tract fill), carcass adjusted (HCW/0.63), and beef production per acre of cropland is presented in Table 3. A silage × implant interaction was detected ($P \leq 0.03$) for initial to d 28 ADG and F:G. steers from PLUS/15 had a greater ADG compared to ONE-F/15 and PLUS/30, while ONE-F/30 was intermediate. Intakes did not differ among treatments during the initial 28 d, and steers from PLUS/15 exhibited the lowest F:G compared to all other treatments. This response is likely a function of rapid implant payout from PLUS coupled with the greater diet energy content of the 15 diet (Johnson et al., 2019; Smith et al., 2019; Smith et al., 2020). There was a tendency ($P = 0.10$) for steers fed 30 to have greater DMI compared to 15 from d 113 to 132. No other differences ($P \geq 0.14$) were detected for the main effects of silage or implant for un-shrunk live basis interim growth performance.

No interaction of silage × implant ($P \geq 0.22$) or the main effects of silage ($P \geq 0.19$) or implant ($P \geq 0.85$) were detected for live-basis cumulative shrunk growth performance in the present experiment. No interaction of silage × implant ($P \geq 0.30$) were detected for carcass-adjusted basis cumulative growth performance in the present experiment. The main effect of silage inclusion level influenced ($P \leq 0.02$) carcass-adjusted final BW, ADG, and F:G. Increased carcass-adjusted final BW, ADG, and improved F:G for the steers fed 15% corn silage was due to differing dressed yield and digestive fill that was not accounted for due to a common pencil shrink that was applied for live basis shrunk growth performance. The main effect of terminal implant did not alter ($P \geq 0.54$) any carcass adjusted growth performance responses in the present experiment. No interaction of silage × implant ($P \geq 0.85$) or the main effects of silage ($P \geq 0.15$) or implant ($P \geq 0.90$) were detected for observed dietary NE based upon performance or the ratio of observed to expected dietary NE in the present study.

No interaction of silage × implant ($P \geq 0.70$) or the main effects of silage ($P \geq 0.13$) or implant ($P \geq 0.56$) were detected for agronomic returns (live basis or carcass-adjusted basis beef produced per acre of cropland) in the present experiment. Interestingly, a near tendency ($P = 0.13$) for greater levels of corn silage inclusion to increase beef production per acre of cropland on a live basis. However, this was not the case on a carcass-adjusted basis, likely for the same reasons illustrated above in regards to a generic pencil shrink application when diets of differing NDF content are fed, and steers are harvested at an equal duration of days on feed. This study does demonstrate that depending upon environmental conditions and workload demands at harvest, that producers can effectively feed greater amounts of corn silage to finishing cattle with no negative impact on beef production per acre of cropland which is major importance to integrated crop-livestock producers.

Carcass trait responses are located in Table 4. No interaction of silage × implant ($P \geq 0.16$) was detected for any carcass trait parameters. Silage inclusion level did not influence ($P \geq 0.16$) REA, RF, USDA marbling score, calculated yield grade, retail yield, estimated EBF, final BW at 28% EBF, or the distribution of USDA Quality or Yield grades. Feeding a lower inclusion level of corn silage in the finishing diet did increase ($P = 0.01$) dressing percentage and increased ($P = 0.02$) HCW. Implant type did not influence ($P \geq 0.14$) dressing percentage, HCW, ribeye area, rib fat, calculated yield grade, retail yield, estimated EBF, body weight at 28% EBF, or the distribution of USDA Quality and Yield grades. Coated implant (ONE-F) did result in greater ($P = 0.02$) marbling scores compared to non-coated implant (PLUS) and this is likely due to alterations of implant type on adipogenic gene expression (Smith et al., 2017; Kim et al., 2018; Smith et al., 2019) although this was not evaluated in the present study.

Implications

These data indicate that feeding greater levels of corn silage in the finishing diet does not influence live basis growth performance, but decreases carcass –adjusted basis growth performance. These differing responses could be exploited depending upon the way cattle are marketed (live or dressed). If steers are sold on a carcass weight basis, a lower level of corn silage can result in greater HCW when cattle are harvested at an equal days on feed. Level of silage in the finisher did not influence agronomic returns per acre of cropland suggesting that depending upon environmental condition and workload demands at harvest time, integrated crop-livestock systems can feed greater levels of corn silage without detriment to returns to a fixed land base. Terminal implant type (coated vs. non-coated) did not influence steer growth performance or HCW, but did influence marbling scores. Use of these differing technologies in practice should be determined upon the method in which the beef cattle are marketed, cost of the implant, and the improvements in revenue for cattle that are rewarded a premium for greater quality grades.

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Tables

Table 1. Experimental diets.[1, 2]

Item	Lo	1 to 98 d (sd)[3]	Hi	(sd)	Lo	99 to 132 d (sd)	Hi	(sd)
Samples, n	15	-	15	-	5	-	5	-
High moisture corn, %	36.03	(0.287)	28.50	(0.314)	-	-	-	-
Dry rolled corn, %	36.61	(0.346)	28.97	(0.397)	73.00	(0.230)	57.87	(0.295)
Corn silage	15.34	(0.445)	30.55	(0.729)	15.24	(0.171)	30.40	(0.277)
Suspension supplement[4], %	5.02	(0.052)	5.00	(0.072)	4.90	(0.065)	4.89	(0.063)
Pelleted supplement[5], %	7.00	(0.063)	6.98	(0.093)	6.86	(0.079)	6.84	(0.075)
DM, %	64.32	(0.667)	54.56	(0.783)	69.59	(0.921)	57.82	(0.752)
CP, %	12.32	(0.459)	12.07	(0.456)	11.85	(0.265)	11.49	(0.298)
NDF, %	13.57	(0.599)	18.53	(1.194)	14.18	(0.402)	19.74	(0.785)
ADF, %	6.12	(0.249)	9.20	(0.484)	6.20	(0.176)	9.37	(0.358)
Ash, %	4.87	(0.115)	5.34	(0.150)	4.83	(0.194)	5.29	(0.254)
NEm[6], mcal/cwt	94.15	(0.097)	90.06	(0.151)	92.81	(0.062)	89.02	(0.076)
NEg[6], Mcal/cwt	63.55	(0.077)	60.29	(0.124)	62.54	(0.045)	59.51	(0.059)

[1] All values except for DM on a DM basis.
[2] Calculated from weekly ingredient assays and feed batching records.
[3] sd = standard deviation
[4] Provided micronutrients to meet or exceed NRC (1996) requirements and contained 648 g/Mg monensin sodium.
[5] Contained (DM basis): 85.70% soybean meal, 2.85% trace mineralized salt, 2.85% urea, and 8.60% dry rolled corn.
[6] Based upon tabular NE values for ingredients (Preston, 2016).

Table 2. Deads and removals excluded interim (un-shrunk) growth performance responses.[1]

	15% CRNSIL		30% CRNSIL				P - value	
Item	**PLUS**	**ONE-F**	**PLUS**	**ONE-F**	**SEM**	**Silage (S)**	**Implant (I)**	**S × I**
Pens, n	5	5	5	5	-	-	-	-
Steers, n	38	37	36	38	-	-	-	-
Initial BW, lbs	838	849	847	845	-	-	-	-
Initial to 28 d								
d 28 BW, lbs	959	952	948	958	9.0	0.66	0.79	0.22
ADG, lbs	4.31^{a}	3.71^{b}	3.61^{b}	4.04^{ab}	0.242	0.31	0.62	0.01
DMI, lbs	17.39^{gh}	17.32^{gh}	16.52^{h}	18.36^{g}	0.780	0.88	0.14	0.11
F:G	4.05^{b}	4.70^{a}	4.58^{a}	4.58^{a}	0.179	0.14	0.03	0.03
d 29 to 56								
d 56 BW, lbs	1073	1058	1066	1075	13.0	0.59	0.80	0.22
ADG, lbs	4.05	3.79	4.21	4.19	0.319	0.23	0.52	0.59
DMI, lbs	20.86	20.35	20.92	21.29	0.429	0.12	0.82	0.17
F:G	5.17	5.41	5.03	5.17	0.378	0.49	0.49	0.84
d 57 to 84								
d 84 BW, lbs	1188	1183	1185	1190	11.4	0.77	1.00	0.54
ADG, lbs	4.11^{h}	4.44^{g}	4.26^{gh}	4.10^{h}	0.188	0.50	0.53	0.09
DMI, lbs	23.75	23.42	23.46	23.70	0.616	0.99	0.92	0.52
F:G	5.79^{gh}	5.31^{h}	5.56^{gh}	5.80^{g}	0.277	0.51	0.56	0.09
d 85 to 112								
d 112 BW, lbs	1299	1291	1285	1287	13.0	0.35	0.77	0.57
ADG, lbs	3.98	3.86	3.56	3.47	0.257	0.05	0.59	0.94
DMI, lbs	25.21	24.44	25.00	24.63	0.550	0.97	0.17	0.61
F:G	6.40	6.47	7.14	7.19	0.482	0.05	0.86	0.97
d 113 to 132								
d 132 BW, lbs	1353	1347	1338	1349	18.4	0.62	0.86	0.51
ADG, lbs	2.72	2.81	2.67	3.10	0.431	0.70	0.41	0.59
DMI, lbs	24.69^{gh}	24.37^{h}	25.84^{g}	25.04^{gh}	0.726	0.10	0.29	0.65
F:G	9.53	9.20	11.50	8.35	1.634	0.64	0.16	0.24
Initial to d 132								
ADG, lbs	3.90	3.78	3.72	3.82	0.123	0.46	0.89	0.22
DMI, lbs	22.27	21.88	22.22	22.51	0.372	0.29	0.85	0.22
F:G	5.70	5.78	5.98	5.90	0.202	0.19	1.00	0.60

[1] No shrink applied to any BW measures.
[a, b] Means within a row without a common superscript differ ($P < 0.05$).
[g, h] Means within a row without a common superscript differ ($P < 0.10$).

Table 3. Deads and removals excluded cumulative live (shrunk) and carcass-adjusted growth performance responses and beef production per acre of cropland.

	15% CRNSIL		30% CRNSIL				P - value	
Item	**PLUS**	**ONE-F**	**PLUS**	**ONE-F**	**SEM**	**Silage(S)**	**Implant (I)**	**S × I**
Pens, n	5	5	5	5	-	-	-	-
Steers, n	38	37	36	38	-	-	-	-
Live basis[1]								
Initial BW, lbs	805	815	813	811	-	-	-	-
Final BW, lbs	1299	1293	1284	1295	17.7	0.62	0.86	0.51
ADG, lbs	3.75	3.63	3.57	3.67	0.118	0.46	0.89	0.22
DMI, lbs	22.27	21.88	22.22	22.51	0.372	0.29	0.85	0.22
F:G	5.94	6.02	6.23	6.15	0.211	0.19	1.00	0.60
Carcass-adjusted basis[2]								
BW, lbs	1330	1324	1298	1301	14.6	0.02	0.86	0.70
ADG, lbs	3.98	3.86	3.68	3.71	0.098	0.01	0.54	0.30
F:G	5.59	5.65	6.03	6.07	0.122	0.01	0.61	0.89
Observed dietary NE, Mcal/cwt								
Maintenance	92.95	92.95	91.47	91.74	2.317	0.43	0.94	0.94
Gain	62.92	62.92	61.63	61.86	2.031	0.43	0.94	0.94
Observed to expected dietary NE[3]								
Maintenance	0.99	0.99	1.02	1.02	0.025	0.15	0.91	0.87
Gain	0.99	0.99	1.03	1.03	0.032	0.23	0.90	0.85
Agronomic return								
Live basis beef produced, lbs/acre	1809	1793	1862	1821	63.0	0.13	0.96	0.70
Carcass-adjusted beef produced, lbs/acre	1926	1907	1914	1901	37.8	0.76	0.56	0.92

[1] A 4% shrink was applied to all BW measures in order to account for gastrointestinal tract fill.
[2] Calculated from HCW/0.63.
[3] Actual diet NE based upon tabular values and diet formulation were: 93.80 Mcal/cwt or NEm and 63.29 Mcal/cwt of NEg for 15 CRNSIL; 89.79 Mcal/cwt of NEm and 60.09 Mcal/cwt of NEg for 30% CRNSIL

Table 4. Carcass trait responses

Item	15% CRNSIL		30% CRNSIL		SEM	P - value		
	PLUS	ONE-F	PLUS	ONE-F		Silage (S)	Implant (I)	S × I
Pens, n	5	5	5	5	-	-	-	-
Steers, n	38	37	36	38	-	-	-	-
Dressing percent[1], %	64.56	64.48	63.69	63.25	0.501	0.01	0.48	0.62
HCW, lbs	838	834	818	819	9.2	0.02	0.86	0.70
REA, in^2	14.47	14.41	14.33	14.24	0.177	0.24	0.55	0.93
RF, in	0.45	0.42	0.44	0.39	0.044	0.53	0.22	0.71
Marbling score[2]	436	451	429	480	17.5	0.42	0.02	0.16
YG	2.67	2.61	2.62	2.52	0.139	0.50	0.43	0.87
Retail Yield, %	50.75	50.88	50.86	51.04	0.279	0.50	0.45	0.88
Estimated EBF, %	28.54	28.32	28.26	28.12	0.676	0.63	0.71	0.93
Final BW at 28% EBF, lbs	1299	1301	1278	1286	19.7	0.23	0.74	0.87
Select, %	31.43	19.64	34.28	19.64	8.459	0.87	0.14	0.87
Choice, %	63.21	70.00	57.03	63.57	8.369	0.46	0.44	0.99
Upper Choice, %	5.36	10.36	8.69	8.58	3.827	0.84	0.53	0.51
Prime, %	0.00	0.00	0.00	8.21	2.812	0.16	0.16	0.16
Y1, %	10.71	16.78	9.17	13.93	5.303	0.68	0.62	0.90
Y2, %	62.86	45.36	55.95	42.14	11.956	0.68	0.21	0.88
Y3, %	26.43	37.86	34.88	43.93	11.479	0.54	0.39	0.92

[1] Calculated as HCW/final BW shrunk 4%.
[2] 400 = small^{00} (USDA Low Choice).