2004

Effects of Supplying Water with Varying Levels of Total Dissolved Solids and Sulfates to Steers During the Growing Period on Subsequent Finishing Performance

Kent E. Tjardes
South Dakota State University

Hubert H. Patterson
South Dakota State University

Cody L. Wright
South Dakota State University

Bradley D. Rops
South Dakota State University

Effects of Supplying Water with Varying Levels of Total Dissolved Solids and Sulfates to Steers During the Growing Period on Subsequent Finishing Performance

Kent E. Tjardes[1], Hubert H. Patterson[1], Cody L. Wright[1], and Brad D. Rops[2]
Department of Animal and Range Sciences

BEEF 2004 – 06

Summary

Previous results have shown that water with elevated total dissolved solids (TDS) and sulfates was detrimental to performance of growing steers. The objective of this study was to determine finishing performance of steers that had previously received different levels of water quality during the growing period. In yr 1, 78 steers (824 lb) were assigned to one of eight pens (2-4 pens/treatment) based on water supplied during the 84-d growing period. Water TDS and sulfates during growing were: 1) 1,020 and 400; 2) 4,840 and 3,090; and 3) 6,190 and 3,950 ppm of TDS and sulfates, respectively. In yr 2, 75 steers (840 lb) that were previously supplied water during a 104-d growing period averaging: 1) 1,230 and 440; 2) 2,930 and 1,730; 3) 4,720 and 2,920; and 4) 7,270 and 4,650 ppm of TDS and sulfates respectively, were received and fed in one pen. In both years, all steers were fed a common finishing diet and had access to rural water. In yr 1, steers receiving treatment 1 had higher ($P < 0.10$) ADG and DMI compared to treatments 2 and 3 during the previous growing period. During the initial 28-d of finishing, treatments 2 and 3 had higher ($P < 0.10$) ADG than treatment 1. Steer DMI was not different ($P = 0.19$) between treatments during the first 28-d. Over the entire 126-d finishing trial, ADG, DMI and carcass characteristics were not different due to treatment ($P > 0.10$). In yr 2, there was a quadratic decline in ADG with increasing TDS ($P < 0.05$) during the previous growing phase, resulting in treatment 4 have lower initial weight ($P < 0.05$) compared to treatments 1, 2, and 3. During the first 28-d of finishing, ADG was higher ($P < 0.10$) for treatments 2 and 3 compared to 1, with treatment 4 being intermediate. Over the 133-d finishing trial, ADG of treatments 2 and 3 was greater ($P < 0.10$) than treatment 1, with treatment 4 being intermediate, resulting in treatment 4 having lower carcass weight ($P < 0.05$) compared to treatments 1, 2 and 3. Other carcass traits were not significantly different due to treatment. Steers receiving water during the growing period with 5000 ppm TDS and 3000 ppm sulfates or less were able to compensate for lost growing performance during the finishing period.

Introduction

Surface and subsurface water available to cattle in South Dakota is often high in total dissolved solids (TDS) and sulfates. Ingestion of high sulfate water causes increased ruminal H_2S generation (Loneragan et al., 1997) and can result in sulfur-associated polioencephalo-malacia (McAllister et al., 1997; Gould, 1998). Previous research at South Dakota State University has demonstrated that supplying water containing high concentrations of TDS and sulfates to growing steers not only increased the incidences in polioencephalo-malacia, but also reduced DMI, water intake, ADG and efficiency of gain (Patterson et al., 2002, 2003).

In a review, Smith (1998) stated that subclinical disease events may be more economically important than clinical events. The reduction in ADG of cattle that suffer from respiratory diseases during the early phases of growth can persist through finishing. The respiratory morbidity not only depresses finishing phase performance but also can reduce carcass weight, fat deposition and ribeye area (Gardner et al., 1999). Loneragan et al. (2001) observed that high sulfate water supplied to feedlot steers at a subclinical level reduced performance. However, it is not known if the depression in growing phase performance, due to poor water quality, will have a lasting effect on performance until cattle are harvested. Therefore, the objective of this study was to determine if supplying water with high concentrations of TDS and sulfates during the growing period had any

[1] Assistant Professor
[2] Research Assistant, SE Research Farm

subsequent effect on finishing performance and carcass characteristics.

Materials and Methods

In this study, steers that were backgrounded at the South Dakota State University Cottonwood Range and Livestock Research Station, near Philip, SD on two previous water quality studies (Patterson et al., 2002; 2003) were shipped to the Southeast South Dakota Experiment Farm, Beresford, SD, to determine the effect of water quality during the growing phase on subsequent finishing phase performance. In yr 1, 78 steers (824 lb) were assigned to one of eight pens (2-4 pens/treatment) based on water supplied during the 84-d growing period (Patterson et al., 2002). Water TDS and sulfates during growing were: 1) 1,020 and 400; 2) 4,840 and 3,090; and 3) 6,190 and 3,950 ppm of TDS and sulfates, respectively. In yr 2, 75 steers (840 lb) that were previously supplied water during a 104-d growing period averaging: 1) 1,230 and 440; 2) 2,930 and 1,730; 3) 4,720 and 2,920; and 4) 7,270 and 4,650 ppm of TDS and sulfates, respectively (Patterson et al., 2003), were received and fed in one pen.

In both years, upon arrival, steers had *ad libitum* access to long-stem grass hay and rural water. The following morning, steers were vaccinated against viral (BOVI-K; Pfizer Animal Health, Exton, PA) and bacterial agents (ULTRABAC 7; Pfizer Animal Health) and treated for internal and external parasites (ivermectin; PROMECTIN B POUR-ON; Vedco, Inc., St. Joseph, MO). All steers were adapted to a common finishing diet (Table 1) using four step-up diets over 21-d, and they had *ad libitum* access to rural water. Diets were mixed once daily and fed at 0800. Bunks were managed to be slick just prior to feed delivery and any feed refusal was weighed and recorded. Complete mixed diets and feed ingredients were sampled weekly and frozen immediately. Samples were later dried at 135˚F, ground through a Wiley mill, equipped with a 1 mm screen, and analyzed for DM (Georing and Van Soest, 1970), CP (macro-Kjeldahl N; AOAC, 1984), and NDF (Van Soest et al., 1991).

Steer weights were taken in the morning prior to feeding at the beginning and end of the trial and every 28-d. Steers were implanted with 120 mg trenbolone acetate and 24 mg estradiol-17β (REVALOR-S; Intervet Inc., Millsboro, DE) on d 28. At the end of the trials (126 and 133 d for yr 1 and yr 2, respectively), steers were processed at a commercial processing plant (PM Beef, Windom, MN) and carcass data was recorded after a 48-h chill.

In yr 1, data were analyzed as a completely randomized design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. The model contained steer initial finishing phase weight, final weight, ADG, DMI, feed efficiency, and carcass data as the dependant variables and growing phase treatment as the independent variable. In yr 2, since all steers were fed in one pen, data were analyzed as a completely randomized design using GLM procedures of SAS with animal as the experimental unit. The model contained steer initial finishing phase weight, final weight, ADG, and carcass data as the dependent variables and growing phase treatment and as the independent variable. Treatment effects for all data were considered different at a significance level of $P < 0.10$.

Results and Discussion

In yr 1, steers that received treatment 1 (1,020 ppm TDS and 400 ppm sulfates) had higher ($P < 0.10$) ADG and DMI compared to steers that received treatment 2 (4,840 ppm TDS and 3,090 ppm sulfates) and 3 (6,190 ppm TDS and 3,950 ppm sulfates) during the previous growing period (Patterson et al., 2002). This resulted in steers on treatment 1 to have higher ($P < 0.05$) final weights than steers on treatments 2 and 3 after the growing period. Once all steers were shipped from the Cottonwood Station to the Southeast Research Farm and allowed access to long-stem hay, the initial finishing phase weights take at Beresford were numerically higher for steers that previously received treatment 1 compared to steers that received treatments 2 and 3, but was not significantly different. This lack of significance was primarily due to an increased in variation of body weights of the steers within treatment. During the initial 28-d of finishing, steers from treatments 2 and 3 had higher ($P < 0.10$) ADG than treatment 1 (Table 2). Steer DMI was not different ($P = 0.19$) between treatments during the first 28-d. Over the entire 126-d trial, ADG, DMI and efficiency of gain were not different due to treatment ($P > 0.40$). This resulted in there being no difference ($P > 0.70$) in final weight and hot carcass weight due to treatment. In addition, there were no differences ($P > 0.20$) in dressing percentage, ribeye area, 12th rib fat thickness, kidney, pelvic and heart fat, USDA Yield Grade, or marbling score.

In yr 2, there was a quadratic decline in ADG with increasing water TDS and sulfate concentrations ($P < 0.05$) during the previous 104-d growing phase (Patterson et al. 2003), resulting in steers that previously received treatment 4 (7,270 ppm TDS and 4,650 ppm sulfates) having lower initial finishing phase weight ($P < 0.05$) compared to steers that received treatments 1 (1,230 ppm TDS and 440 ppm sulfates), 2 (2,930 ppm TDS and 1,730 ppm sulfates), and 3 (4,720 ppm TDS and 2,920 ppm sulfates). During the first 28-d of finishing, ADG was higher ($P < 0.10$) for treatments 2 and 3 compared to 1, with treatment 4 being intermediate (Table 3). Over the 133-d trial, ADG of treatments 2 and 3 was greater ($P < 0.10$) than 1, with treatment 4 being intermediate. This resulted in treatment 4 having lighter final weight and carcass weight ($P < 0.05$) compared to treatments 1, 2 and 3. However, dressing percentage, ribeye area, 12th rib fat thickness, kidney pelvic and heart fat, USDA yield grade and marbling score were not different ($P > 0.20$) due to treatment.

Results of these trials suggest that steers that received water with intermediate concentrations of TDS and sulfates during the growing phase were able to compensate for lost growth performance during the initial part of the finishing period in which they received rural water. Additionally, this loss in performance in the early stages of growth did not have lasting effects on carcass characteristics. Steers that received water above 7,000 ppm TDS and 4,500 ppm sulfates during the growing phase had adequate finishing phase gains compared to the control steers, but they did not compensate for the lost body weight that occurred during the growing phase. Other than the reduction in carcass weight, supplying water with high concentrations of TDS and sulfate did not adversely affect any of the other carcass parameters measured. Loneragan et al. (2001) observed that the reduction in steer performance was the greatest during the early stages of growth when water that contained sulfates greater than 583 ppm was supplied during the finishing period. Steers in the study of Loneragan et al. (2001) appeared to adapt to high sulfate water during the latter stages of trial, but this compensation was not enough to overcome the loss in body weight that occurred early in the finishing period. Besides the reduction in hot carcass weight, Loneragan et al. (2001) reported that dressing percentage and predicted yield grade decreased linearly with increasing water sulfate concentration

Implications

Water quality continues to be a concern in the Northern Great Plains and Western United States. Water with high concentrations of total dissolves solids, especially those that contain high concentrations of sulfates, can have negative effects on growing phase performance of cattle. However, in the current research, steers receiving water during the growing period with 5000 ppm TDS and 3000 ppm sulfates or less were able to compensate for lost growing performance during the finishing period. Water extremely high in total dissolved solids and sulfates provided to younger cattle may cause reductions in the final weight of the cattle.

Literature Cited

AOAC. 1984. Official Methods of Analysis. 14th ed. Association of Official Analytical Chemists, Arlington, VA.

Gardner, B. A., H. G. Dolezal, L. K. Bryant, F. N. Owens, and R. A. Smith. Health of finishing steers: Effects on performance, carcass traits, and meat tenderness. J. Anim. Sci. 77:3168-3175.

Goering, H. K., and P. J. Van Soest. 1970. Forage Fiber Analysis (Apparatus, Reagents, Procedures, and Some Applications). Agric Handbook No. 379. ARS-USDA, Washington, DC.

Gould, D. H. 1998. Poliencephalomalacia. J. Anim. Sci. 76:309-314.

Loneragan, G. H., D. H. Gould, J. J. Wagner, F. B. Garry, and M. A. Thoren. 1997. The effect of varying water sulfate content on H_2S generation and health of feedlot cattle. J. Anim. Sci. 75(Suppl. 1):272(Abstr.).

Loneragan, G. H., J. J. Wagner, D. H. Gould, F. B. Garry, and M. A. Thoren. 2001. Effects of water sulfate concentration on performance, water intake, and carcass characteristics of feedlot steers. J. Anim. Sci. 79:2941-2948.
McAllister, M. M., D. H. Gould, M. F. Raisbeck, B. A. Cummings, and G. H. Loneragan. 1997. Evaluation of ruminal sulfide concentration and seasonal outbreaks of polioencephalomalacia in beef cattle in a feedlot. J. Am. Vet. Med. Assoc. 211:1275-1279.
Patterson, H. H., P. S. Johnson, T. R. Patterson, D. B. Young, and R. Haigh. 2002. Effects of water quality on animal health and performance. Proc. West. Sec. Amer. Soc. Anim. Sci. 53:217-220.
Patterson, H. H., P. S. Johnson, and W. B. Epperson. 2003. Effects of total dissolved solids and sulfates in drinking water for growing steers. Proc. West. Sec. Amer. Soc. Anim. Sci. 54:378-380.
Smith, R. A. 1998. Impact of disease on feedlot performance: A review. J. Anim. Sci. 76:272-274.
Van Soest, P. J., J. B. Roberson, and B. A. Lewis. 1991. Symposium: Carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. J. Dairy Sci. 74:3583-3597.

Tables

Table 1. Composition of diet fed to steers during finishing (Year 1 and 2)

Ingredient	% of diet DM
Cracked corn	79.00
Alfalfa hay	10.00
Molasses	3.50
Supplement	
Ground corn	3.20
Dicalcium phosphate	0.24
Limestone	0.83
Corn oil	0.13
Potassium chloride	0.18
Soybean meal, 44% CP	1.56
Urea	0.80
Trace mineralized salt[a]	0.51
Rumensin 80[b]	0.10
Tylan 40[c]	0.02
Vitamin A[d]	0.01

[a]Contained (%): Na, 37.0; Zn, 0.35; Fe, 0.2; Mn, 0.2; Cu, 0.03; I, 0.007; Co, 0.005.
[b]Contained 80 g of monensin per lb.
[c]Contained 40 g of tylosin per lb.
[d]Contained 30,000 IU vitamin A per gram.

Table 2. Influence of water with varying concentrations of total dissolved solids (TDS) and sulfates offered to steers during the growing phase on subsequent finishing performance (Year 1)

Treatment	1	2	3	
TDS/sulfate, ppm[a]	1,020/400	4,840/3,090	6,190/3,950	SEM
n	2	2	4	
Initial wt., lb	844	806	822	18
d 0-27				
ADG, lb/d	2.91^{b}	3.40^{c}	3.38^{c}	0.24
DMI, lb/d	19.5	18.8	19.7	0.3
Gain:Feed	0.150	0.182	0.172	0.011
Feed:Gain	6.71	5.57	5.86	0.34
Final wt, lb	1303	1289	1300	29
Trial (d 0-126)				
ADG, lb/d	3.64	3.75	3.80	0.19
DMI, lb/d	21.7	21.5	22.4	0.60
Gain:Feed	0.168	0.175	0.169	0.004
Feed:Gain	5.97	5.74	5.93	0.16
Hot carcass wt., lb	795	788	801	30
Dressing, %	61.2	61.1	61.6	0.5
Fat thickness, in	0.53	0.43	0.52	0.05
KPH, %	1.93	1.74	1.89	0.11
Ribeye area, in^2	12.74	13.00	12.59	0.32
USDA Yield Grade	2.79	2.41	2.81	0.20
Marbling[d]	577	600	567	24

[a]Average total dissolved solids and sulfates concentrations in water supplied to steers during the 84-d growing phase (Patterson et al., 2002).
[b,c]Means with different superscripts differ ($P < 0.10$).
[d]Slight^0=400; Small^0=500; Modest^0=600.

Table 3. Influence of water with varying concentrations of total dissolved solids (TDS) and sulfates offered to steers during the growing phase on subsequent finishing performance (Year 2)

Treatment	1	2	3	4	
TDS/sulfates, ppm[a]	1,230/440	2,930/1,730	4,720/2,920	7,270/4,650	SEM
Initial wt., lb	854^{b}	852^{b}	845^{b}	785^{c}	18
d 0-29 ADG, lb/d	4.10^{d}	4.69^{e}	4.67^{e}	4.25^{de}	0.30
Final wt, lb	1433^{c}	1472^{c}	1468^{c}	1363^{d}	30
Trial ADG, lb/d	4.35^{d}	4.67^{e}	4.68^{e}	4.33^{d}	0.16
Hot carcass wt., lb	851^{b}	865^{b}	867^{b}	801^{c}	18
Dressing, %	59.5	58.8	59.1	58.8	0.4
Fat thickness, in	0.61	0.61	0.62	0.52	0.05
KPH, %	2.36	2.17	2.19	2.16	0.08
Ribeye area, in^2	12.72	12.92	13.18	12.29	0.34
USDA Yield Grade	3.66	3.61	3.56	3.34	0.12
Marbling[g]	568	607	595	582	22

[a]Average total dissolved solids and sulfates concentrations in water supplied to steers during the 104-d growing phase (Patterson et al., 2003).
[b,c]Means with different superscripts differ ($P < 0.05$).
[d,e]Means with different superscripts differ ($P < 0.10$).
[f]Slight^0=400; Small^0=500; Modest^0=600.