POTASSIUM REQUIREMENTS FOR COW/CALF OPERATIONS

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Introduction

Potassium is found mainly within the cells of the animal body and is a dietary essential for all animals (Table 1). It is widely distributed in feed sources but the levels are highly variable (Table 2). Overt deficiencies are seldom encountered in animals. Usually forages are higher in potassium than concentrates. Forages that have been subjected to weathering may contain low levels of the element (Table 3). Potassium is absorbed mainly from the upper small intestine, but some absorption also occurs in the lower small intestine and the large intestine (12). Absorption from the intestine appears to be by simple diffusion (4,12).

The main functions of potassium in the animal are for osmotic equilibrium, maintenance of acid base balance, enzyme reactions for phosphorylation of creatine, pyruvate, kinase activity, cellular uptake of amino acids, carbohydrate metabolism, protein synthesis, and maintenance of normal heart and kidney tissue. Excess potassium is usually excreted through the urine. Aldosterone and sodium intake affect potassium excretion. The hormone increases sodium reabsorption in the kidney, and there is usually an inverse relationship between sodium and potassium excretion. Erythrocytes contain about 25 times as much potassium as the plasma. Muscle and nerve cells are also very high in potassium and more than 20 times as much as intersticial fluids.

Karne and Clanton (3) conducted a series of experiments to determine the effect of potassium supplementation on weight change in weanling steer calves and bred cows during native winter range. When the data from the three experiments were analyzed together weight gains were increased when potassium was added to a supplement containing urea. The appropriate level of supplemental potassium was not determined but the results of these experiments indicate that supplements fed to weaning calves at the rate of 1½ pounds per head per day on native winter range should contain at least 2% potassium. Waggoner et al. (10) reported a positive effect from supplemental potassium with bred cows on Wyoming native winter range. Two supplements, one with 2.25% potassium and the other with 4.15% were fed at the rate of 1½ to 2 pounds per head per day during the winter. The cows that received the higher level potassium lost less weight during the winter and calving. Their calves were 11 pounds heavier at weaning than those on the lower level of potassium. Kothman and Hinnant (5) reported that supplemental potassium fed to wintering beef cows on pasture produced calves that were 37 pounds heavier in April than calves from cows not receiving supplemental potassium. Cows receiving extra potassium lost less weight from November to April. Their conception rate was 60%, compared to 40% for the control group. These three studies show evidence for the benefits of supplemental potassium under winter grazing conditions and demonstrate that potassium can be a limiting nutrient for cattle on winter range.

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The purpose of these studies was to evaluate supplemental levels of potassium and its effects on wintering cow and calf performance.

Colorado State University - Study 1

Eighty crossbred gestating cows were selected for stage of gestation from a larger group and randomly assigned to treatments in a randomized block design. Cows were blocked on weight and stratified in treatments to equalize body condition score, projected calving date and cow breed. Treatments included four levels of potassium included in a cottonseed meal based range cube that provided 5, 17 [redacted], [redacted] 55 and [redacted] 106 grams of supplemental potassium per head daily during gestation and continued through a short lactation period (Table 4). Cows were maintained in one of four approximately 120 acre pastures and cows were rotated to a new pasture to allow ad lib forage access. Cows were gathered 3 times a week, individually stalled and fed their respective supplement and remained in the stalls until all supplement was consumed (usually not more than 15 minutes). Feeding K supplement started November 26, 1991 and cow performance measurements ended April 15, 1992, while calf performance was monitored through July 29, 1992. Cows were weighed unshrunk on two consecutive days at the beginning and end of the trial with full weights obtained every 28 days during the study. Cows were also weighed every two weeks starting in March to obtain the last precalving weight. Calves were weighed within 24 hours of birth.

Body condition score was estimated at the beginning, calving and end of the trial using a 9 point scoring system (Scale of 1 = very thin and 9 = very fat,) (11).

A loose mineral mix containing 49.5% dicalcium phosphate, 49.5% trace mineralized salt and 1% $CuSO_4$ was available free choice throughout the trial in a mineral feeder. During the study, 805 lbs of this mix was offered.

When there was snow cover that prevented grazing, millet hay was supplemented at the rate of 13 lbs/head/day from 1/1/93 through 1/8/93. Ammoniated wheat straw was supplemented at the rate of 21 lbs/head/day from 1/9-1/15 and at 9.2 lbs/head/day from 1/23-1/27. Millet hay provided an additional 154 grams of K when it was fed while ammoniated wheat straw provided 95 and 42 grams of additional K per head per day at the two supplementation rates, respectively. Otherwise, dormant native range forage was grazed at the Eastern Colorado Research Center located 18 miles north of Akron, Colorado, in the sandhills of northeastern Colorado. Elevation averages 4266 feet above sea level and the topography varies from nearly level to slightly rolling, sandy plains. Vegetation is heterogeneous, consisting of short, mid and tall grasses as well as both cool-season and warm-season species. The major grasses are blue gramma (Bontelous gracilis), prairie sandweed (Calamovilfa longifolia), needle-and-thread (stipa comata), sand bluestem (Andropogan hallii), western wheatgrass (Agropyron smithii), and sand dropseed (Sporobolus cryptandrus). Forbs common to the area include perennial ragweed (Ambrosia coronopifolia), cudweed sage (Artemisia indoviciana), wild alfalfa (Psoralea tenuiflora), and bush morning glory (Lponcea leplahylla).

Data were analyzed by analysis of variance for a randomized block design according to the GLM procedure of SAS (7) (1985). When significant differences were found, means separation was made using Duncans Multiple Range Test (Steel and Torrie) (9).

Results and Discussion

Two cows were removed from the study. One died from post partum complications and another had triplets. During the 138 day study, supplemental forage was fed 26 days due to snow cover of dormant winter range. Potassium content of sand hills winter range has been measured from .09 to .11 percent from November to March with a rather large increase in potassium content in April (3). Samples of dormant winter native range grass analyzed 0.17% potassium and 4.6% crude protein (dry matter basis) at the beginning of the trial. Based on dry matter intake of 1.8% of body weight, cows should have consumed approximately 15 grams of potassium/head/day from native winter range. Forage intake plus supplement intake would be equal to .21, .35, .75 and .87% K on a dry matter basis during gestation assuming 20.4 lbs of dry matter consumption per cow per day. Upon receipt of the laboratory analysis of the K content of millet hay (2.9% K dry matter basis) ammoniated wheat straw was chosen as the forage to feed on snow days since it was much lower in potassium content (1.1% K). Feeding millet hay supplied an additional 1.66% K to all treatments for 8 days. Feeding ammoniated wheat straw supplied an additional 1.0 and 0.4% K for seven and five days, respectively. Hay and straw feeding was required due to snow cover, however, it might have reduced treatment difference somewhat during gestation. Cow weight change from 12/24 through 1/21 (28 days) was .33, -.31, -.88 and -.48 lbs/day for the 1.37, 3.58, 8.52 and 12.23% K treatments, respectively. Clanton (1) (1980) suggested that the potassium requirement of pregnant beef cows was between .5 and .7 percent. Livestock needs for potassium vary with amounts of protein, phosphorus, calcium and sodium consumed (4).

During the approximate 104 day gestation and supplementation period, cows fed the 12.23% K supplement gained significantly faster than cows fed any of the other supplements (Table 5). Cows fed the low level of potassium chloride (3.58% K) lost more weight during gestation than cows fed either no potassium chloride (1.37% K) or 8.52% K in the supplement.

Weight loss during lactation tended to be less ($P>.05$) for cows fed the 3.58% K treatment compared to the other K levels. This may have been partially the result of cows fed this treatment losing more weight during gestation and consequently becoming more efficient during lactation. However, lactation weight change was not significantly affected by treatment and may have been partially due to the short lactation period. The trial was ended when cows could not be gathered for penning by one person. Their refusal to be gathered in this manner was due to the growth of green grass in mid April. The loss in weight during lactation may have been reduced with a higher level of protein supplementation during this period of the trial.

Cows had a body condition score of 5.0 at the beginning of the trial. By April 15th, cows fed 3.58% supplemental potassium lost ($P<.05$) more condition than cows fed the

12.23% supplemental potassium. During early lactation, the greatest BCS loss appeared to occur within cows fed 12.23% K. Supplemental potassium fed to wintering cows did not significantly affect calf weight gain from birth until the end of the supplemental feeding period (approximately 28 days). Nine cows had not calved by the end of the supplemental feeding period, April 15th. However, they all did calve by May 1st. Calf average daily gain (birth to 133 days of age) was not statistically influenced by supplemental potassium fed to wintering cows. However, the average July 29th weight of calves from cows fed supplemental potassium chloride was 24 lbs heavier than the July 29th weight of calves from cows fed no supplemental potassium chloride during the winter. K supplementation may have possibly influenced lactation response. Since the cow supplementation period only lasted 19.2% of the time represented by the period from birth to July 29th, it is difficult to attribute the heavier July 29th calf weight to only K supplementation during early lactation (i.e., the first 25 days). Two calves from cows fed the 1.37% K supplement died in June from IBRV.

Estimated pregnancy rate as of September 24, 1992 was not affected significantly by wintering potassium level. Breeding season started the first of June and consequently one would not expect to influence pregnancy rate with these treatments.

The data suggest that supplementing 66 g K per head per (12.23% supplemental K) day was beneficial to weight change of gestating cows compared to cows supplemented with 3.58% K. The 12.23% K level plus estimated K intake from dormant winter range grass would be equivalent to approximately .57% K on a dietary dry matter basis. The second best gestation weight change was observed with the low level of K supplementation (i.e., K coming from cottonseed meal, primarily). By the end of the supplementation period, weight changes were about the same. Pregnancy rates were high and did not appear to be influenced by potassium supplementation. It is perplexing that the 3.58% K supplemented group lost more gestation weight than the control group (1.37% K). Gestation weight and condition score change observations suggest that 12.23% K supplementation may not be sufficient to optimize wintering cow performance.

Colorado State University - Study Two

Ninety-six crossbred gestating cows were selected from a larger group by stage of gestation (estimated by rectal palpation) and randomly assigned to one of three treatments in a randomized block design. Cows were also blocked on weight and stratified in treatments to equalize body condition score and projected calving date. Treatments included three potassium levels supplied in a cottonseed meal-based range cube that provided 7, 47 and 78 g of supplemental K per h daily during gestation, and then supplementation was continued through a short lactation period (Table 6). Cows were maintained in one of four approximately 120 acre pastures, and the cows were rotated to a new pasture to allow ad libitum forage access. All cows were kept in the same pasture to reduce pasture affects. Cows were gathered three times a week, individually stalled, fed their respective supplement and remained in the stalls until all supplement was consumed which was usually not more than 15 min. Feeding of the K supplement started November 13, 1992 and measurements of cow performance ended April 14, 1993. Cows were weighed unshrunk on two consecutive d at the beginning and end of the trial with full weights obtained every 28 d during the study. Cows were also weighed every two weeks starting in March to obtain the last precalving weight. Calves were weighed within 24 h of birth. Calves were weaned on 8/9/93 and cows were pregnancy checked via rectal palpation on 10/14/93.

A loose mineral mix containing 49.5% dicalcium phosphate, 49.5% trace mineralized salt, and 1% $CuSO_4$ was available free choice throughout the trial in a mineral feeder.

Blood was collected from all cows 2/14/93 via jugular puncture and analyzed for serum K and washed red blood cell (RBC) K. Samples were collected approximately 24 hr after one of the three weekly feedings.

Data were analyzed by analysis of variance for a randomized block design according to the GLM procedure of SAS (7) (5). When significant differences were found, means separation was made using Duncan's multiple range test (7).

Colorado State University - Study 2

Potassium content of sandhills winter range has been reported to be .09 to .11% from November to March with a rather large increase in K content in April (3). Dormant winter native range grass analyzed .19% K and 4.8% crude protein (dry matter basis) at the beginning of this trial. Based on dry matter intake of 1.8% of body weight, cows should have consumed approximately 19 g of K per h per d from standing winter forage.

Due to the snow cover and the required supplemental feeding of energy (Table 7) which contributed higher levels of K than standing winter forage would have provided, treatment differences due to supplemental K may have been minimized. Cows fed the 47 and 78 g/h/d supplemental K tended to have less gestation weight loss than those supplemented with 7 g K (Table 8). Weight loss during lactation tended to be less for cows fed the 94 g/h/d supplemental K compared to the other levels tested.

Condition scores at calving were significantly higher for cows fed the 47 or 78 compared to the 7 g/h/d K supplement. It also appeared that cows fed the two lower levels of K may have tended to compensate more in putting on body condition during lactation than those cows that were fed 78 g supplemental K.

Supplemental potassium did not affect percent pregnant as of 10/14/93. Potassium supplementation did not significantly influence serum K or washed RBC K.

Potassium supplementation did not affect calf birth weight or average daily gain through 4/14 (Table 9). Numerically the best calf average daily gain appeared to be from calves whose mothers were supplemented with 9.5% K compared to the other levels. Stanton et al. (8) observed a similar trend when K was supplemented at 8.5% K. Weaning weights (8/9/93) were not significantly different among treatments.

This study suggests that supplementing 47 g K (9.5%) per h per d was beneficial in reducing gestating cow weight loss. Stanton et al. (8) observed that supplementing 66 g K (12.2% of supplement) improved gestation weight change compared to supplemental K levels of 5, 17 and 55 g/h/d. The lower level response observed in this study may have been due to the additional energy supplementation that also contributed to dietary K. There also appeared to be a trend for reducing condition score loss at calving with supplemental K. Assuming cows were consuming 1.8% of their body weight on a dry matter basis of standing winter range that contained 19 g K plus 47 g K from the supplement would suggest a dietary K level of .66% may be close to their dietary requirement. The NRC (6) recommendation of .65% would appear to be adequate for wintering beef cows. Clanton (1) suggested that the potassium requirement of dry pregnant beef cow is between .5 and .7%. This study would suggest that the requirement may be closer to .7% than to .5%.

Implications

This study and a previous study (Stanton et al.,) (8) demonstrated benefits from K supplementation in reducing late gestation weight loss and body condition score loss during winter. K supplementation may be a more economical way to minimize moderate reductions in cow body weight and condition than supplementation with additional energy or protein.

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Table 1. Distribution of potassium.

Tissue or Organ	Potassium Content % of Total K
Muscle	56.0
Skin	11.1
Digestive Tract	5.6
Liver	5.3
Red Blood Cells	4.2
Blood Plasma	2.2
Brain	1.4
Kidney	0.9
Lung	0.5
Spleen	0.4
Heart	0.4
Bones and other Organs	12.0

Table 2. K content of feedstuffs.

	% K
Low K Sources	
Urea	0.00
Corn gluten meal	0.02
Wood molasses	0.03
Rice	0.15
Corn	0.29
Fish meal	0.29
Milo	0.35
Oats	0.37
Wheat	0.42
Barley	0.49
Marginal K Sources	
Meat scraps	0.55
Hominy feed	0.61
Wheat germ meal	0.78
Wheat shorts	0.85
High K Sources	
Wheat bran	1.23
Linseed oil meal	1.38
Cottonseed meal	1.47
Cond. fish solubles	1.70
Soybean oil meal	2.00
Alfalfa meal	2.02
Cane molasses	2.60
Double sulfate of potassium & magnesium	18.00
Potassium sulfate	41.00
Potassium chloride	50.00

Table 3. Potassium content of Nebraska native winter range.

North Platte		Sand Hills	
Date of Collections	Potassium as % of DM	Date of Collections	Potassium as % of DM
Dec. 1973	1.07	Dec. 1974	.09
Jan. 1974	.46	Jan. 1975	.09
Feb. 1974	.23	Feb. 1975	.10
Mar. 1974	.15	Mar. 1975	.11
Apr. 1974	.57	Apr. 1975	.59

Again, note the very low potassium values during winter feeding.

Table 4. Supplement Composition (% As Fed)

	Analyzed Percent Potassium (DM Basis)			
Ingredient	**1.37**	**3.58**	**8.52**	**12.23**
CSM (41% CP)	90.00	86.40	79.75	73.35
SBM (46.5% CP)	6.50	6.10	5.35	4.65
Potassium Chloride		4.00	11.40	18.50
Beet Molasses	3.50	3.50	3.50	3.50
	100.00	100.00	100.00	100.00
Feeding Rate[a]				
Gestation lbs fed/hd	1.01	1.06	1.14	1.19
Lactation lbs fed/hd	1.50	1.54	1.72	1.80
Supplemental K Levels (g/hd)				
Gestation	5	17	55	66
Lactation	10	23	62	93

[a] Cows were fed 3 times per week. To calculate the amount per feeding, multiply by 7 and divide by 3.

Table 5. Effect of Potassium Chloride Supplementation on Wintering Cow Performance

Item	Percent Potassium (DM Basis) in Supplement				SE
	1.37	3.58	8.52	12.23	
Number Head	20	20	19	19	
Initial Wt. (lb)	1135	1142	1124	1140	21.8
Cow Performance					
Trial Days in Gestation	105	105	104	103	1.21
Gestation ADG (lb)	.35[b]	-.09[c]	.18[b]	.62[a]	.09
Trial Days in Lactation	27	24	25	27	1.68
Lactation ADG (lb)	-1.01	-.02	-1.17	-1.12	.24
Condition Score					
Initial 11/29/91	5.0	5.0	5.0	5.0	.07
At Calving	4.2[ab]	3.8[b]	4.2[ab]	4.4[a]	.07
Score 4/15/92	4.0[a]	3.4[b]	3.7[ab]	3.7[ab]	.08
Change (Initial-At Calving)	-.8[ab]	-1.2[b]	-.8[ab]	-.6[a]	.09
(Initial - 4/15 Score)	-1.0[a]	-1.6[b]	-1.3[ab]	-1.3[ab]	.09
% Pregnant as of 9/24/92[d]	100	100	94.7	100	1.28
Est. Days Gestation (9/24)[d]	100	98	93.0	98	2.60
Calf Performance (lb)					
Birth Weight	87	91	92	87	1.5
4/15 Weight	140[a]	138	146	139	2.7
ADG (Birth to 4/15)	1.89	1.69	2.16	1.91	.07
7/29 Weight	376	387	414	400	6.14
ADG (Birth to 7/29)	2.2	2.22	2.44	2.35	.09

[abc] Means with different superscripts differ ($P<.05$).
[d] Estimated via rectal palpation.

Table 6. Supplement composition (% as fed)

Ingredient	Treatments (Analyzed % K DM basis) 1.7	9.5	14.4
Cottonseed meal (41% CP)	86.5	69.85	63.46
Soybean meal (46.5% CP)	10.0	8.15	7.44
Potassium chloride		18.50	25.60
Beet molasses	3.50	3.50	3.50
Total	100	100	100
$/ton	259.00	278.30	285.54
Feeding rate[a] (lb/h/d)			
Gestation	.99	1.23	1.34
Lactation	2.00	2.46	2.68
Supplemental K levels (g/h)			
Gestation	7	47	78
Lactation	14	94	156

[a]Cows were fed three times per week. To calculate the amount per feeding, multiply by 7 and divide by 3.

Table 7. Supplemental feeding due to snow cover

Item	Wheat Hay	Ammoniated Straw	Alfalfa	Corn	Oat Hay
Days fed	72	10	12	57	45
Amount fed (lb/h/d)	14.7[be]	11[c]	21.3[d]	62[ae]	11[a]
Potassium (g/d)	137	8	149	8	183

[a]Fed together from March 1-April 14 (44 d).
[b]Fed November 24-December 26 (32 d); January 18-February 28 (41 d).
[c]Fed December 17-January 6, 1993 (11 d).
[d]Fed January 7-17 (10 d).
[e]Fed together February 17-28 (11 d).

Table 8. Potassium level and winter cow performance

Item	1.7% K	9.5% K	14.4% K	SEM
Number of cows	32	32	32	
On test wt (lb)	1225	1214	1225	11
Wt change (lb/d)				
Gestation	-.44	-.29	-.24	.07
Lactation	-1.74	-1.41	-2.86	.24
D gestation	93	95	96	1.29
D lactation	23	23	22	.73
Condition score				
On test (11/12/92)	5.4	5.5	5.5	.06
At calving (3/4/93)	3.6[b]	4.0[a]	4.1[a]	.07
Off test (4/14/93	4.2	4.5	4.3	.06
Change (on test - at calving)	-1.9	-1.5	-1.5	.08
Percent pregnant 10/14/93	96.9	96.9	96.9	.02
K mEq/1 serum	4.24	4.49	4.34	.065
K mEq/1 washed RBC	23.1	18.5	21.0	.10

[a,b]Means in a row with different superscripts differ ($P<.01$).

Table 9. Calf performance

Item	1.7% K	9.5% K	14.4% K	SEM
Number of calves	32	28	27	
Birth wt (lb)	88	88	86	1.39
Average days on test	25	25	22	1.16
Birth--off test ADG (lb/d)	1.80	2.00	1.85	.07
4/14 wt (lb)	137	140	128	2.77