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Potassium nutrition of heat-stressed lactating dairy cows

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Two experiments were performed to assess dietary supplementation to enhance potassium status and production responses of heat-stressed lactating dairy cows. Elevated temperatures reduced feed consumption and milk yield. Feed intake and milk yield were higher when 1,08% K compared with 0,66% K was included in the diet, but not at the 1,64% K level. When supplemental potassium was provided by $KHCO_3$ (rather than KCl), feed consumption and milk yield declined by 11%.

Twee eksperimente is uitgevoer om die invloed van dieetaanvulling op die verhoging van kalium status en produksie-reaksie van lakterende melkkoeie wat aan hittedruk onderwerp is, te bepaal. Verhoogde temperature verlaag voerverbruik en melkopbrengs. Voerinname en melkopbrengs was hoër wanneer 1,08% K ingesluit is in die rantsoen, teenoor 0,66% K, maar nie op die 1,64% vlak nie. Wanneer kaliumaanvulling voorsien is deur $KHCO_3$ (eerder as KCl), het voerverbruik en melkopbrengs gedaal met 11%.

Keywords: Potassium, macrominerals, heat stress, lactation

Introduction

Florida lies in a subtropical region (24°32′ to 31°N latitude). Environmental heat stress significantly affects dairy cattle performance annually over a 5 month period. When Black Globe Temperature (BGT), an integrated measure of dry bulb air temperature, wind velocity and solar radiation, rises above 29°C, feed intake and production are reduced. Many responses to heat stress, such as increased respiration and sweating rates, are survival strategies aimed at maintaining normal body temperature. These typically compromise maximum production and optimum efficiency (Collier, Beede, Thatcher, Israel & Wilcox, 1982).

In 1978, 401 Florida dairies averaged 491 cows each, with about 60 dairies having over 1,000 cows (Wilcox, Van Horn, Harris, Head, Marshall, Thatcher, Webb & Wing, 1978). Complete mixed diets are common (60–70% concentrates and 30–40% roughage). Many feeds, particularly cereal concentrates and by-product feeds, may be low in potassium (less than 0,8% on a dry basis).

We hypothesized that heat-stressed lactating cows may have higher dietary potassium requirements because of: (a) lactational stress associated with high production and high milk potassium content (0,15–0,17%), (b) heat stress owing to increased body potassium loss through sweating and decreased daily potassium intake and (c) diets often contain considerable low potassium feeds. Two experiments were performed to assess dietary supplementation to enhance potassium status and production responses of heat-stressed lactating cows.

Experimental

Experiment I

Objectives were to assess production and physiological responses of cows to varying dietary potassium (0,66; 1,08; 1,64%; dry basis) when in a no shade (NS) or shade (S) management system.

Methods

Ten Holstein (mid-lactation) and eight Jersey (early-lactation) cows were blocked by breed and assigned to NS open lot or S structure with an adjoining open lot (Roman-Ponce, H., Thatcher, W.W., Buffington, D.E., Wilcox, C., 1977), in a split-plot (NS or S as main plots) with a 3 × 3 Latin Square (period and dietary potassium level) as sub plots. All cows received different dietary potassium treatments in each 30-day period. Basal diet was 52% ground corn, 9,5% corn gluten meal, 1,0% urea, 34% cottonseed hulls, minerals and vitamins. Potassium chloride replaced small amounts of corn to achieve appropriate potassium treatments. Other nutrients were formulated to meet 1978 NRC recommendations. *Ad libitum* feed intake of individual cows was measured between 0800–1700 and 1700–0800h daily for the last 2 wks of each period. Milk yield was measured twice daily at (0700 and 1630h) and BGT was monitored hourly from 1100–1800h. On day 29 of period 2 sweat secretions were collected to measure relative skin potassium loss during 2 h intervals at 0900, 1300 and 2000h.

Results and Discussion

Average BGT was 44,1 vs 33,5°C for NS and S. Respiration rate (RR) (132 vs 88/min) and rectal temperature (RT) (41,2 vs 39,9°C) were greater in NS. Dietary potassium treatment did not not effect RT or RR. Total daily feed intake was greater in S than NS (21,3 vs 18,7 kg). Daytime feed intake was depressed 56% in NS (4,0 vs 9,2 kg). NS cows consumed increasing amounts of feed as potassium levels increased, suggesting higher potassium enhanced dry matter intake (3,7; 4,0 and 4,7 kg at 0,66; 1,08 and 1,64% potassium). At night feed intake was 19,5% greater in NS than S (14,7 vs 12,3 kg) suggesting an attempt to compensate for reduced daytime intake.

Morning milk yield was 23% greater in S (9,6 vs 7,8 kg). Evening yield was 27% higher in S (8,1 vs 6,4 kg). Curvilinear effect of dietary potassium on milk yield was observed for morning and evening milkings. Total daily milk yield was 20% lower in NS (14,2 vs 17,7 kg). Curvilinear effect of potassium on total daily milk yield was noted with 0,66; 1,08 and 1,64% potassium of 15,2, 16,6, 16,1 kg/d. Milk yield improved as potassium level increased from 0,66 to 1,08%. However, increasing the level to 1,64% provided no additional benefit. Considered within environment, response to added potassium from 0,66 to 1,08% was greater in NS (12% increase) than S (6% increase). This suggested additional beneficial response to dietary potassium in heat-stressed cows.

Figure 1 illustrates the effects of environment on relative skin potassium secretion rate. The rate was greater in NS than S in every sampling interval. During peak heat load (1300–1500 h), potassium secretion rate was about 5-fold greater in NS.

Results suggested lactating cows could be in a rather precarious negative potassium balance during heat stress. This coupled with major loss of potassium in milk, certainly presents a different osmotic and electrolyte regulation dilemma for cows experiencing heat stress than for normothermic cows.

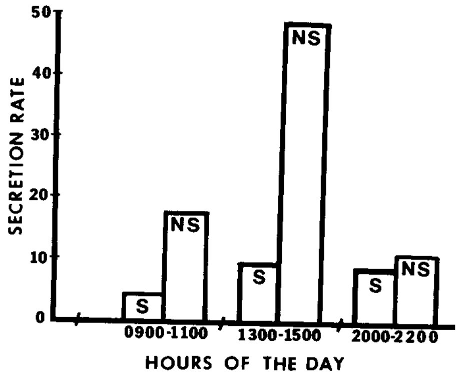

Figure 1 Effect of no shade (NS) or shade (S) environment on relative secretion rate of potassium from the skin (mg/m^2/h).

Experiment II

Objectives were to evaluate effects of heat stress, total dietary potassium, dietary potassium bicarbonate ($KHCO_3$) and sodium bicarbonate ($NaHCO_3$) on production responses. It was postulated that mineral buffers might increase efficiency of fermentation by increasing ruminal pH. Also, $KHCO_3$ might serve as a source of bicarbonate and supplemental potassium.

Methods

Experimental design was a split-plot in which environment was NS or S. Within each environment was a 2 × 2 × 2 factorial arrangement of eight dietary treatments. Dietary treatments were 0 and 0.85% $NaHCO_3$, 0 and 1.0% $KHCO_3$, and 1.08 and 1.63% total dietary potassium. Basal diet was 25% cottonseed hulls, 58% ground corn, 10% corn gluten meal, urea, vitamins and minerals. Twenty four Holstein cows in early to mid lactation were assigned randomly to each environment and dietary treatment. Cows remained in each environment throughout but received a different dietary treatment in each of three 35 d periods.

Results and Discussion

Average daily BGT (0900–1600 h) was 29,1°C for S and 41,0°C in NS. Rectal temperatures at 1300h averaged 39,2°C in S and 40,8°C in NS. Respiration rates for cows in S averaged 85 vs 130/min in NS. Respiration rates even in S indicated hyperthermia, but were lower than in NS.

Table 1 shows production responses to dietary treatment and environment. Environment affected feed intake and milk yield. Feed intake and yield of cows in S increased by 8,6% and 4,7%, with inclusion of $NaHCO_3$. Similar but not significant trends were observed in NS.

Added $KHCO_3$ had a negative effect on feed intake and milk yield in NS. Lower intake of treatments containing $KHCO_3$ might be due to low palatability. In four treatments $KHCO_3$ contributed about half of the total potassium to each (KCl provided the rest). This may explain the lower intake in NS at 1,63% than at 1,08% total dietary potassium. There was a significant interaction of $KHCO_3$ and total dietary potassium on feed intake. Despite lower feed intake with 1,63% total dietary potassium compared to 1,08%, milk yield was higher with higher total dietary potassium.

Table 1 Dietary treatment and environmental effects on production responses, Experiment 2

Dietary Treatment	% of Ration DM	Feed intake (kg/d)[a] Shade	Feed intake (kg/d)[a] No shade	Milk Yield (kg/d)[a,b] Shade	Milk Yield (kg/d)[a,b] No shade
$NaHCO_3$	0,00	19,8	16,5	19,0	16,8
	0,85	21,5*	17,2	19,9*	17,2
$KHCO_3$	0,00	21,1	17,8	19,3	18,0
	1,00	20,2	15,9*	19,6	16,0*
Total K	1,08	20,7	17,4	19,2	16,8
	1,63	20,6	16,3*	19,7	17,3*
Environmental Effects		20,6	16,8**	19,4	17,0**

a Least squares means.

b Feed intake as covariate.

* ($P < 0,05$) significant for dietary treatments only between appropriate pairs of means.

** ($P < 0,01$) significant for environmental effects.

Conclusions

As demonstrated by the NS and S model, elevated temperatures reduced feed consumption and milk yield, suggesting altered potassium metabolism and nutrition due to heat stress. This is probably due to lower feed intake (and, thus, potassium intake) and greater loss of body potassium through sweating in NS compared to S cows. In Experiment 1, increasing potassium from 0,66 to 1,08%, increased feed intake and milk yield in NS cows. However, increasing total dietary potassium from 1,08 to 1,64% resulted in decreased yield and feed consumption.

In Experiment 2, similar increases were noted in milk yield of NS cows with higher dietary potassium (1,08 to 1,63%). However, when supplemental potassium was provided by $KHCO_3$ (rather than KCl), feed consumption and milk yield declined 11%.

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