Slow Release Somatotropin in Dairy Heifers and Cows Fed Two Levels of Energy Concentrate. 1. Performance and Body Condition

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ABSTRACT

Fifty-two Holstein dairy cows (27 primiparous) were used in a 2 × 2 factorial design during wk 9 to 39 of lactation to assess the effects of slow release recombinant bST (500 mg injected at 14-d intervals) and the effects of the level of energy concentrate in the diet on dairy performance. After a winter period, cows were turned out to pasture at wk 24 of lactation.

During winter, cows given low concentrate (2.5 vs. 5.4 kg DM/d) ate significantly more corn silage (13.9 vs. 11.9 kg DM/d), so that treatment had no significant effect on any measured parameter. The milk yield of bST-supplemented cows increased by 2.1 kg/d (11.0%) throughout the total experimental period. The response did not differ according to parity. Milk fat content and SCC were not altered, but milk protein was lower (.8 g/kg) from cows receiving bST during winter, and lactose increased (.5 g/kg). Lactation curves of bST-supplemented cows showed a cyclic response in milk production. Gross efficiency of milk yield was improved (.18 units) by bST administration without change in diet digestibility. No difference due to bST was found in the health or reproduction of cows.

Live weight change did not differ among the groups. Multiparous cows gained body condition (bST-supplemented animals gained less than controls: .1 vs. .7 point on a five-point scale; NS). Control primiparous cows gained body condition (.1 point) but bST-supplemented cows significantly lost body condition (1.4 point).

(Key words: somatotropin, dairy performance, body condition)

Abbreviation key: PDI = protein digestible in the intestine.

INTRODUCTION

The effects of pituitary-derived bST and, more recently, recombinant bST have been studied extensively in dairy cattle (13, 20). Supplementation with bST increased milk yield up to 40% above that of controls with large interassay variations that were related to bST dose and injection frequency, management, or other unknown factors. Response in primiparous cows was the same as in multiparous in some studies but lower in others (4, 6).

Some evidence suggests that nutritional factors are important for optimizing milk yield, decreasing the mobilization of body stores, and keeping the normal interval from calving to conception in bST cows (16). Indirect comparison of 46 bST trials has shown different positive responses according to the use of complete mixed rations (5.4 kg/d, n = 28, most of these trials from the United States), separate forages and concentrate (3.4 kg/d, n = 10), or pasture (2.5 kg/d, n = 8, most of these trials from Europe) (6). Direct comparisons of different diets in bST trials of several weeks or several months were reviewed by Chalupa and Galligan (4). Response to bST tended to be higher, but not always, with diets of higher nutritive value (concentrate percentage, dietary buffers, supplementary fat, or proteins).

The present trial was conducted to investigate interactions between concentrate level, parity, and bST on the performances of dairy

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cows receiving a diet based on corn silage as the sole winter forage followed by pasture as the sole summer forage.

MATERIALS AND METHODS

Animals and Feeding

Fifty-two Holstein dairy cows (27 primiparous, 23 to 37 mo of age at calving, and 25 multiparous in their second to eighth lactation) were fed during the dry period preceding experimental lactation so as to calve in good body condition [expected score of 3.5 to 4 in a scale with notation (24) from 0 to 5]. Cows calved from the second half of October to the end of December 1986 and were maintained under the same management during the first 14 d postpartum. At wk 3 of lactation, on the basis of lactation number, calving date, milk yield at wk 2 of lactation, BW, and condition score at wk 1 after parturition, cows were allotted into two nutritional groups: high or low level of energy concentrate in the diet but with the same theoretical protein supply. In the high concentrate group, the cows received daily 2.5 Mcal NE_L (approximately 1.5 kg of concentrate) over recommendations (15), whereas in the low level group, they received 4.2 Mcal NE_L (approximately 2.5 kg of concentrate) under recommended amounts.

The recommended supply of energy and protein was calculated for each cow from the expected weekly milk yield, estimated for the whole lactation from the milk produced during the first 2 wk of lactation. For these computations, we used standard lactation curves recorded in the same herd. We expected the low concentrate group to compensate half of the difference in concentrate supply (approximately 4 kg less than the high concentrate group) by an increased intake of corn silage, which was offered for ad libitum intake and mixed with the concentrate. Consequently, in order to equalize the dietary protein supply, cows of the low concentrate group received in their concentrate 140 g/d less of protein digestible in the intestine (PDI) (29) than the cows of the high concentrate group since corn silage contained 70 g PDI/kg DM (15). The modulation of PDI supply in the concentrate was reached by combining energy-rich and protein-rich concentrates (Table 1). During the grazing period, after wk 24 (SE = 2) of lactation, cows of the low

TABLE 1. Chemical composition of the feeds and composition of the mean diets ingested by each nutritional group during the winter period.

	Chemical composition[1] of the feeds (% in DM)			Level of concentrate	
	OM	CF	CP	High	Low
				(% of DM)	
Corn silage[2]	94.5	18.8	9.2	68.8	84.4
Protein-rich concentrate[3]	92.5	8.1	47.3	4.2	9.6
Energy-rich concentrate[4]	92.8	10.4	13.7	24.3	3.5
Urea	100	...	288	1.2	1.0
Mineral-rich concentrate[5]	13.2	...	...	1.5	1.5
Nutritive value of the diets per kg DM					
Energy, Mcal NE_L				1.61	1.64
CP, g				152	157
PDI, g				89	95

[1]CF = Crude fiber, PDI = protein digestible in the intestine.

[2]Containing 39% DM of grain.

[3]Formaldehyde-treated soybean (80%) and rapeseed (20%) meals.

[4]Ingredients (%): wheat, 10; maize, 10; barley, 32; dehydrated alfalfa, 10; dry beet pulps, 25; soybean meal, 5; wheat bran, 5; dicalcium phosphate, 1.5; calcium bicarbonate, 1; salt, .5.

[5]Commercial supplement containing 22.3% Ca; 8.3% P; 10% NaCl; 4% Mg; 2% S; 4000 ppm Zn; 3000 ppm Mn; 800 ppm Cu; 60 ppm I; 20 ppm Co; 5 ppm Se; vitamins (per 100 kg of feed): vitamin A, 25,000,000 UI; vitamin D_3, 8,000,000 UI; vitamin E, 10 g.

concentrate group were fed concentrate from a milk yield of 11 kg higher than the yield from which the high concentrate group began to receive concentrate. The level of milk yield expected to be maintained by grass alone declined during the grazing season according to grass availability and quality.

Somatotropin Supplementation

At wk 9 of lactation (57 to 63 d postpartum) cows were once again allotted using the same criteria as before; half of each nutritional group was assigned to biweekly subcutaneous administration at the right or left shoulder alternately of 500 mg of recombinant methionyl bST in a slow-release preparation (Sometribove®, Monsanto, St. Louis, MO) or placebo for controls. Each cow received 15 injections (wk 9 to 39 of lactation). The dose of bST preparation was incompletely injected in 25 of the 375 injections due to cow agitation or to great viscosity of the product.

Measurements and Analyses

Cows were milked twice daily at 0600 and 1500 h. Milk yield was recorded daily during the first 14 d postpartum, then four times weekly until the end of the winter period, and twice weekly during the grazing period. Over a 3-wk period (from March 16 to April 5) beginning after the 5.9th (± 1.5) injection, milk yield was recorded daily to characterize day to day changes induced by bST. On each day, fat, protein and lactose contents were measured by infrared spectrophotometry and SCC by automatic counting (Milkoscan 605 and Fossomatic, respectively, Foss Electric, Hillerod, Denmark).

Cows were weighed three times between the 3rd and 8th d of lactation, then biweekly during the winter period, and once a month during the grazing period. Body condition was scored at wk 1, 8, and 21 postpartum, at the 1st wk of the grazing period, and at the end of bST supplementation (wk 39 ± 3 of lactation).

Feed intake was measured daily during the first 7 d of lactation, then 4 d weekly during the winter period. Digestibility of high or low concentrate diets was measured on 12 cows (3 bST-supplemented and 3 control cows in each nutritional group that were in their 12th ± 1 wk of lactation) by total collection of feces for 5 d. Dry matter, ash, N, and crude fiber of feeds and feces were determined.

The cows were artificially inseminated using the same bull semen first after synchronization of estrus between d 46 and 88 of lactation (12 ± 12 d after the first bST injection) and thereafter on subsequent returns. Conception was confirmed based on last service and the interval from last AI to calving. Calves were weighed at birth. All health events occurring through the trial were recorded.

Computations and Statistical Analysis

Data from the winter period (wk 9 to 18 of lactation, which were common for all cows), grazing period (April 27 to August 5), and total experimental period (wk 9 to 39 of lactation) were analyzed using a linear model of variance-covariance analysis as follows:

$$Y_{ijke} = \mu + A_i + B_j + C_k + d(X_l) + AC_{ik} + BC_{jk} + Cd(X_{kl}) + e_{ijkle}$$

where

Y_{ijke} = dependent variable;
μ = overall mean;
A_i = effect of parity (primiparous or multiparous);
B_j = effect of level of energy concentrate (high or low);
C_k = effect of supplementation (bST or placebo);
$d(X_l)$ = covariate for pretreatment adjustment;
AC_{ik} = parity × bST interaction;
BC_{jk} = concentrate × bST interaction;
$C_d(X_{kl})$ = covariate × bST interaction;
e_{ijkle} = residual.

Covariate $d(X_l)$ was dropped out of the model for the estimation of parity effects.

In the analysis of milk yield, feed intake, nutritional balances, feed efficiency, BW, and condition score, the covariate was the mean value of milk yield measured during the first 14 d of lactation. However, milk composition varied greatly during this period. In addition, milk yield declined at wk 4 to 8 postpartum (Figure 1) because of enteritis, which affected most of the multiparous cows during about 2 wk per cow. For these reasons, because the level of energy concentrate was without any effect on milk yield and composition when tested before bST supplementation, another covariate (the mean value of the corresponding trait during wk 1 to 8) was used for the estimation of bST effect on milk composition. The stage of lactation at the end of the winter period was used as second covariate for the analysis of data from the grazing period. One heifer with teat wart (low concentrate group) and one cow with pericardite (high concentrate group), both supplemented with placebo, were removed from statistical analysis of the winter experimental period, and 2 other cows with mammary injury (low concentrate, placebo group) or endocardite (high concentrate, bST group) were excluded from data of the grazing period.

Effect of bST on diet digestibility was estimated using level of intake (DMI/live weight, g/kg) and proportion of concentrate (% DMI) as covariates, and their interactions with bST.

For individual weekly nutritional balance computations, the energy value of corn silage was calculated (1) from its OM digestibility. The OM digestibility was estimated according to a linear regression established from the 12 individual digestibility data, taking into account significant effects of concentrate proportion (CON, % DMI) ($P < .05$) and of level of intake (DMI/live weight, g/kg) ($P < .01$): OM digestibility (%) = 95.9 – .779 DMI/live weight – .116 CON; $r^2 = .80$. Energy and protein contents of other diet components, as well as needs for maintenance and milk yield were from Institut National de la Recherche Agronomique (15).

From the 48 cows retained for performance analysis, 10 were slaughtered during the dry period following the experiment for another experimental purpose and were discarded from the reproduction study. In the calf weight anal-

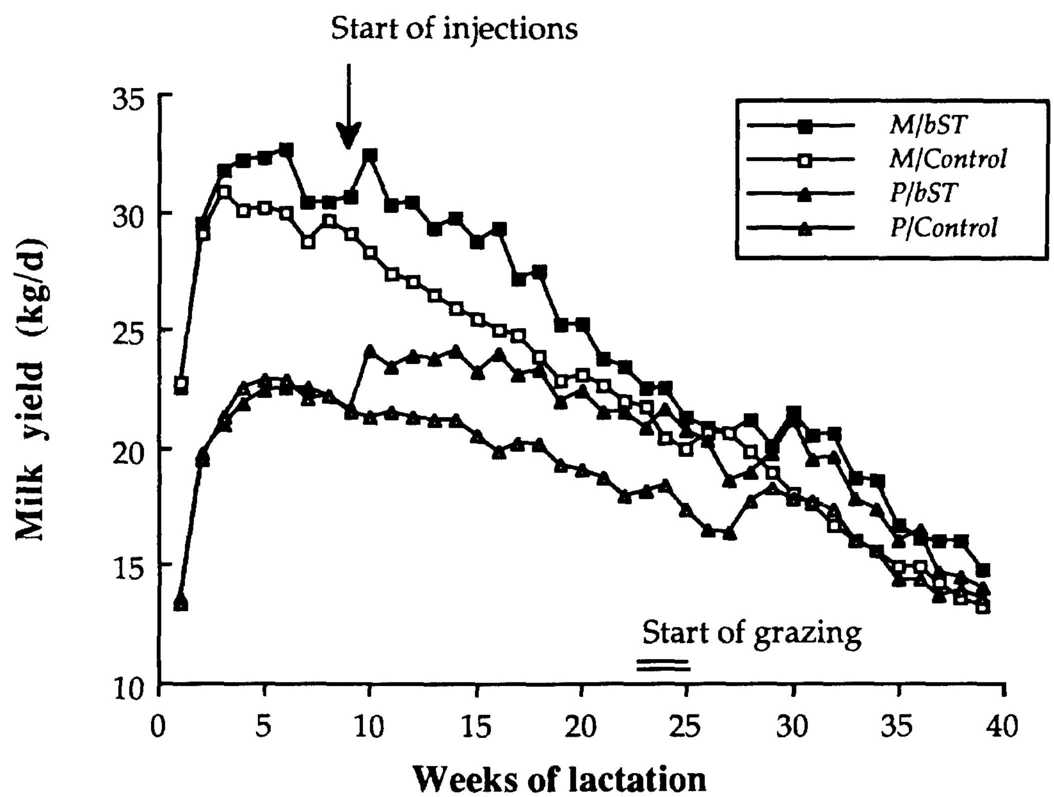

Figure 1. Weekly milk yield in controls [12 multiparous (M); 11 primiparous (P)] and bST-supplemented cows (11 M; 14 P).

ysis, calf sex and the weight of the mother were used as covariates. Seven calves were removed: two sets of twins (1 of bST and 1 of control group) and 3 calves that were stillborn (2 of control group) or died (1 of bST group) within hours after birth. We used probability of 5% unless otherwise noted.

RESULTS

Milk Yield and Composition

Level of concentrate had no effect on milk production and composition at any period (Table 2) or on interaction with bST effect. Milk yield response to bST averaged 2.7 ($P < .01$), 2.0, and 2.1 kg through winter, grazing, and total experimental periods, respectively. The bST did not interact significantly with parity. The individual variability in milk production was not altered by bST during the experimental periods (winter, grazing, and total period) as based upon by similarities in treatment variances. The bST did not significantly affect milk fat content at any period but tended to decrease protein content ($P < .10$) during the winter period (Table 2). It increased lactose content slightly during winter ($P < .10$) and total period and caused increases in yield of milk fat (63 g/d), lactose (105 g/d), and protein (53 g/d) through the total experimental period.

Milk secretion curves showed a cyclic pattern with one peak between two injections (Figure 1). Milk yield response (calculated by individual difference with yield at wk 8, and corrected for mean persistency in the control groups) was apparent from the first bST injection (Figure 2). It peaked 10 to 11 d later (3.2 ± 1.3 kg (14.5%) and 4.2 ± 2.9 kg (14.1%) above primiparous and multiparous control cows, re-

TABLE 2. Effects of concentrate level and bST on milk yield and composition.

	Concentrate[1]				Estimated effects[2]				
	High		Low						
	Control	bST	Control	bST	Concentrate level		bST treatment		Residual[3]
Winter period, wk 9 to 18 postpartum									
Milk yield, kg/d	23.2	25.8	24.1	26.4	–.5	NS	2.7	**	3.2
Fat, g/kg	39.0	37.7	37.9	41.0	–.7	NS	–.1	NS	2.7
Protein, g/kg	29.8	28.6	28.9	28.6	.3	NS	–.8	†	1.5
Lactose, g/kg	47.2	48.5	47.1	47.6	–.4	NS	.4	†	.9
SCC,[4] 10^3/ml	354	347	410	122	1.3	NS	.8	NS	35
Grazing period, April 27 to August 5									
Milk yield, kg/d	16.7	19.0	17.5	18.5	–.4	NS	2.0	*	2.6
Fat, g/kg	38.1	37.2	38.5	38.8	–.4	NS	–1.1	NS	2.6
Protein, g/kg	31.3	32.1	31.9	32.2	–.2	NS	.4	NS	1.5
Lactose, g/kg	46.2	47.7	46.2	46.9	.2	NS	.7	NS	1.2
SCC,[4] 10^3/ml	508	432	408	465	1.2	NS	1.0	NS	19
Total experimental period, wk 9 to 39 postpartum									
Milk yield, kg/d	18.7	21.1	19.6	21.2	–.3	NS	2.1	*	2.7
Fat, g/kg	39.2	38.3	39.1	40.8	–.9	NS	–.6	NS	.3
Protein, g/kg	30.9	30.9	31.0	31.1	–.2	NS	.1	NS	1.5
Lactose, g/kg	46.7	47.8	46.2	47.2	.2	NS	.5	*	.9
SCC,[4] 10^3/ml	451	386	406	310	1.2	NS	.9	NS	18

[1]Unadjusted means.

[2]Level of concentrate (high minus low) and bST (bST minus control) effects estimated after adjustment to covariate were significant: †$P < .10$, *$P < .05$, **$P < .01$, NS = $P > .10$.

[3]Standard deviation or CV in percentage for log-transformed variable.

[4]A logarithmic transformation was employed for statistical analysis. Treatment effect is expressed as the ratio (high: low; bST:control) of antilog values coming from adjusted means of log-transformed data.

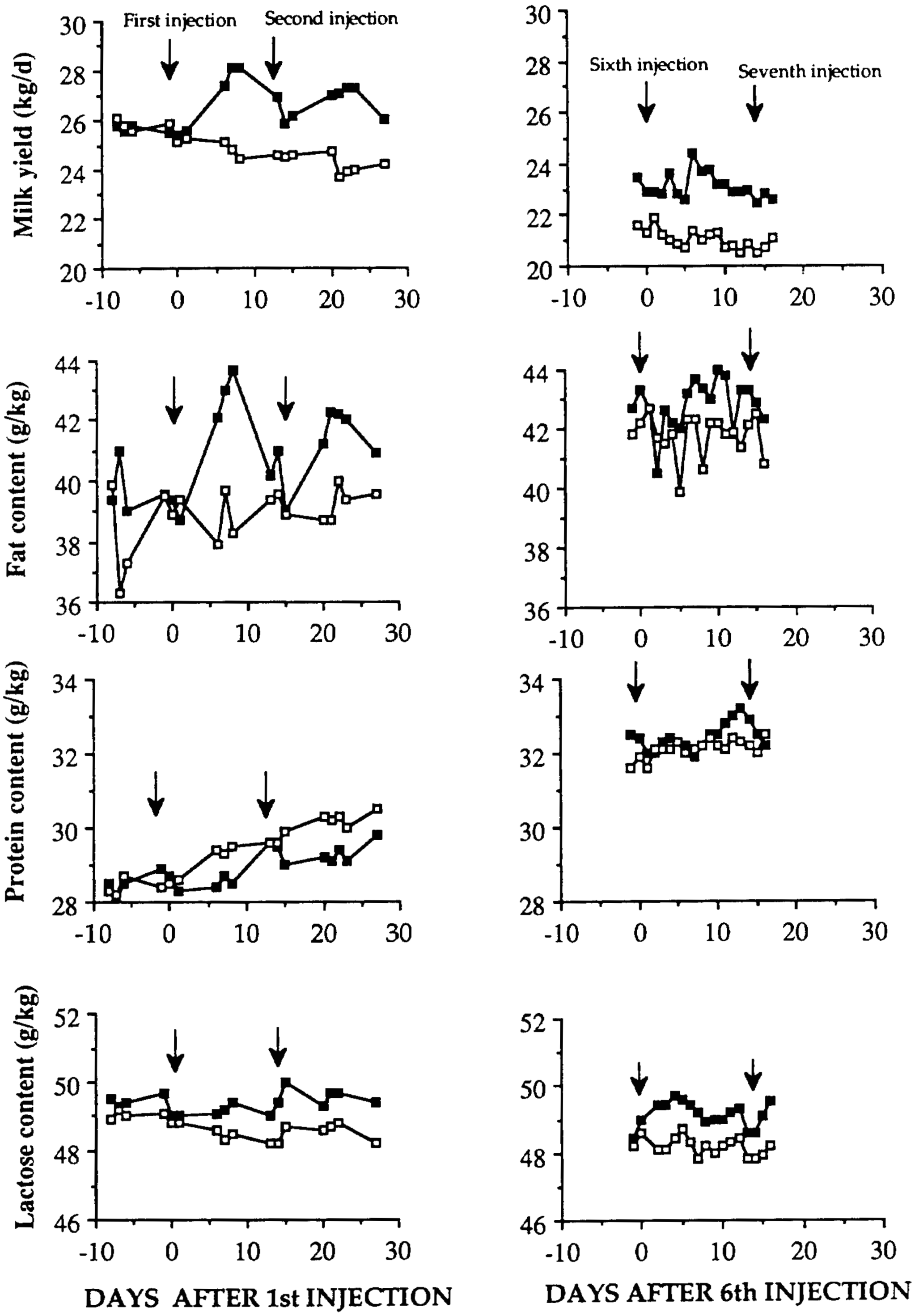

Figure 2. Daily milk yield and composition in controls (n = 24, □) and bST-supplemented cows (n = 26, ■) after the first, second, and sixth injections.

TABLE 3. Effects of concentrate level and bST on feed intake, energy and protein intake and balance, and feed efficiency.

	Concentrate[1]				Estimated effects[2]				
	High		Low		Concentrate level		bST Treatment		Residual SD
	Control	bST	Control	bST					
Winter period, wk 9 to 18 postpartum									
DMI, kg/d	17.6	17.0	16.5	16.5	.9	NS	–.2	NS	1.4
Concentrate intake, kg/d	5.44	5.39	2.48	2.61	2.9	**	.06	NS	.55
Energy intake, Mcal NE_L/d	28.3	27.3	27.0	27.2	.9	NS	–.3	NS	2.4
Protein intake,[3] g PDI/d	1558	1508	1565	1565	–2.1	NS	–18	NS	149
Energy balance, Mcal NE_L/d	2.47	.23	1.07	–1.27	1.45	*	–2.30	**	2.02
Protein balance, g PDI/d	39	–49	59	–27	–21	NS	–87	**	95
Feed efficiency,[4] kg/kg	1.31	1.45	1.41	1.62	–.13	**	.18	**	.45
Grazing period, April 27 to August 5									
Concentrate intake, kg/d	1.54	1.60	.28	.25	1.25	**	.02	NS	.42

[1]Nonadjusted means.

[2]Level of concentrate (high minus low) and bST (bST minus control) effects estimated after adjustment to covariate were significant: $*P < .05$, $**P < .01$, NS = $P > .10$.

[3]PDI = protein digestible in the intestine.

[4]4% FCM/DMI.

spectively) then declined until the next injection while remaining at higher levels than in controls. The magnitude of the first response was unrelated to either preexperiment body condition score (r = .02, n = 26) or pretreatment milk yield (r = .12, n = 26). Milk composition also cycled after the first and second bST injections (Figure 2). Milk fat content increased at the same time as milk yield, but milk protein content cycled in a reverse manner. Changes in milk lactose content were of less magnitude.

TABLE 4. Digestibility of the diet.

	Organic matter	*P*	Crude fiber	*P*
Overall mean, %	72.9		62.7	
Sources of variation				
bST minus control	–.28	NS	–1.81	NS
Concentrate[1]	.02	NS	–.24	.01
Intake[2]	–.64	.05	–.95	.01
r	.84		.93	
Residual SD	1.16		1.46	

[1]Slope [in digestibility (%)/concentrate (% DM)] and significance of the covariate. Mean and range of concentrate in the diet: 21.7% (9.2 to 32.3).

[2]Slope [in digestibility (%)/level of intake (g DMI/kg BW)] of the covariate. Mean and range of DMI (kg/d): 18.2 (14.3 to 23.5).

The cyclicity of milk composition after bST injections seemed to decline during the course of treatment as shown by observations of day to day evolutions after the sixth injection (Figure 2).

Feed Intake, Diet Digestibility, and Nutritional Balances

During winter, cows given a low level of energy concentrate ate a significantly higher amount of corn silage (Table 3) than those groups receiving high levels, so total DMI was not significantly different. Energy and PDI did not significantly differ between nutritional groups during the winter period. In the 12 individual digestibility data, the increase in level of intake significantly decreased OM and crude fiber digestibilities (Table 4). Crude fiber digestibility also was reduced ($P < .01$) by increasing concentrate (% DMI). Administration of bST had no effect on either total DMI (Table 3) or digestibility of diet components (Table 4). Calculated energy and protein balances were significantly reduced by bST supplementation (Table 3, Figure 3).

Supplementation with bST significantly improved efficiency of conversion of feed into milk (Table 3), whereas high concentrate level reduced feed efficiency.

Body Weight and Condition Score Changes

The level of concentrate had no effect on BW and condition score changes nor did it interact with bST (Table 5); bST did not modify live weight changes during the winter period, but it significantly decreased body condition. At the beginning of the grazing period, live weight declined abruptly in all cows (Figure 4), then all cows gained live weight, but bST-supplemented cows recovered more ($P < .01$) live weight and less condition score than controls (Table 5). During this period (Figure 4), multiparous cows gained condition score and bST-supplemented cows slightly (but not significantly) less than controls (.2 vs. .4 point), but primiparous cows lost body condition, the bST-supplemented cows losing significantly more than controls (1.3 vs. .3 point, $P < .01$). Through the total experimental period, live weight gains were not significantly different among groups, but body condition score decreased ($P < .01$) with bST administration (Table 5).

Health Events and Reproductive Performances

No clinical disorders due to bST were detected in cows. A local inflammatory nodule of 2 to 6 cm in diameter appeared at the injection site in all cows in the days following bST administration and was entirely resorbed after 2 wk. This was not observed with the placebo. Throughout the experiment, 7 cows required

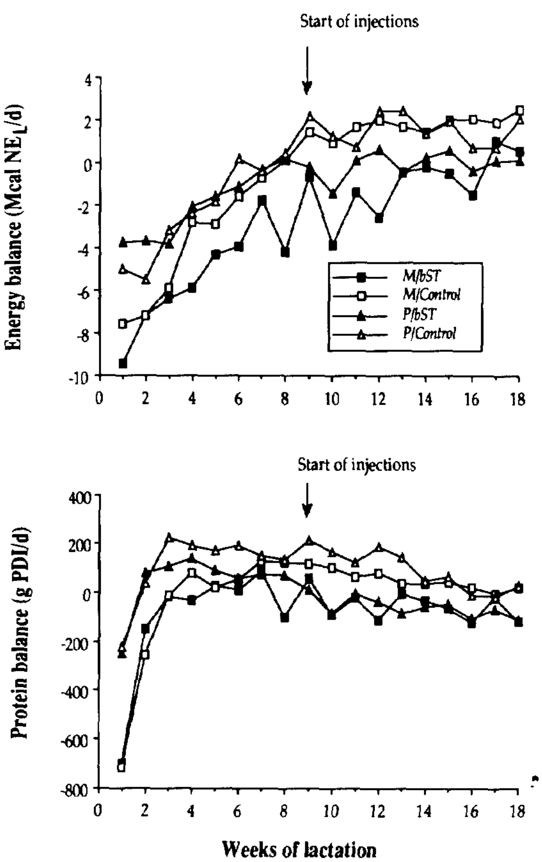

Figure 3. Energy and protein balances of control and bST-supplemented cows during the winter period. PDI = Protein digestible in the intestine, P = primiparous cows, M = multiparous cows.

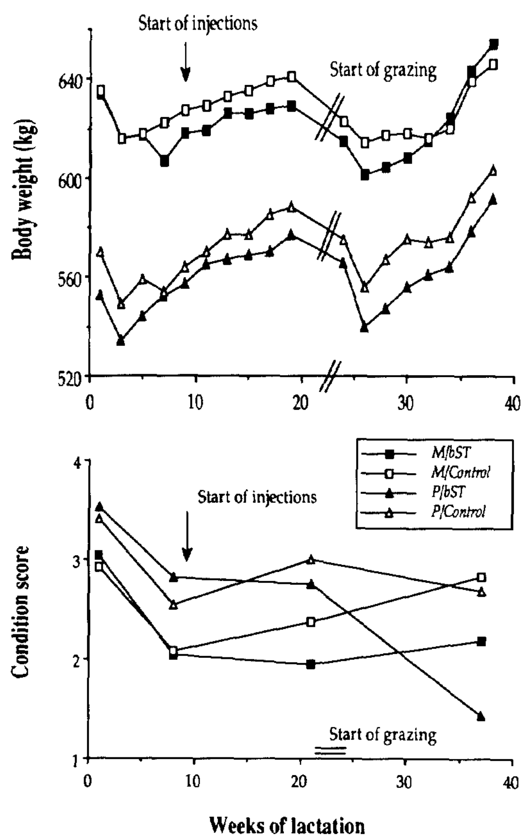

Figure 4. Evolution of BW and condition score in control and bST-supplemented cows throughout the trial. P = Primiparous cows, M = multiparous cows.

TABLE 5. Effects of concentrate level and bST on changes in body weight and condition score.

	Concentrate[1]				Estimated effects[2]				
	High		Low						
	Control	bST	Control	bST	Concentrate level		bST treatment		Residual SD
Winter period[3]									
BW Change, kg	19.4	20.4	20.8	14.5	1.5	NS	−2.7	NS	15.6
Condition score change	.55	−.14	.17	−.04	.20	NS	−.42	**	.49
Grazing period									
BW Change,[4] kg	5.9	29.1	9.2	25.9	.2	NS	17	**	17.6
Condition score change[5]	.05	−.90	−.08	−.37	−.07	NS	−.50	*	.62
Total period									
BW Change,[6] kg	23.1	36.2	25.7	32.4	1.5	NS	7.1	NS	26.2
Condition score change[7]	.55	−1.00	.33	−.46	−.03	NS	−1.04	**	.77

[1]Nonadjusted means.

[2]Level of concentrate (high minus low) and bST (bST minus control) effects estimated after adjustment to covariate were significant: $^{*}P < .05$, $^{**}P < .01$, NS = $P > .10$.

[3]Mean value of wk 16 to 18 minus wk 6 to 8 for live weight, and wk 21 minus wk 8 for condition score.

[4]Week 37 ± 3 of lactation minus 1st wk of the grazing period.

[5]Week 39 ± 3 minus 1st wk of the grazing period.

[6]End of bST administration minus mean value of wk 6, 7, and 8 of lactation.

[7]End of bST administration minus wk 8 of lactation.

antibiotherapy for mastitis without statistical difference due to bST, and milk SCC were not significantly affected by bST (Table 2). No bST-related difference was found in conception rate, interval from calving to conception, length of pregnancy, or calf birth weight (Table 6).

DISCUSSION

The approximate 11% increase of milk yield (2.1 kg) in this trial was significant but ranked among the low responses previously reported in cows receiving similar doses (500 mg/14 d) of slow release recombinant bST (6) but it is unknown if this result was due to characteristics of the animals or due to their management. In our study, the magnitude of the milk yield response to bST was not different according to parity. In the literature, a lower response of primiparous cows has been reported in some bST studies but not in others (4). Milk yield potential also could be suspected, but in the present trial, response to the first bST injection was not related to pretreatment milk yield. In previously reported trials with prolonged-release bST (11, 22), milk yield response was higher, although milk yield of control cows was not higher than in our study. Low producers responded more than high yielding cows in some studies (4), but Peel et al. (21) calculated that milk response was related to the pretreatment milk yield (r = .58) in 45 field trials. However, it is difficult to assess valid comparisons between studies due to possible differences in management (4, 6). We did not find any relationship between condition score at the start of bST supplementation and the milk yield response of individual cows, which is in agreement with a similar relation calculated between herds by Peel et al. (21) (r = .02, n = 23).

Nutritional management also can account for the relatively low response to bST obtained in this study. Several arguments supporting this

TABLE 6. Cow reproductive performance.

	Control	bST	SD
Number of cows	17	21	
Number of pregnancies	15	19	
Services per cow, number	2.1	1.9	1.2
Interval, calving to last AI, d	102	100	35
Length of pregnancy, d	286	285	5
Calf weight,[1] kg	45	48	6

[1]Calculated on 29 calves.

hypothesis should be considered. First dietary concentrates (energy and proteins) were supplied in predetermined amounts according to predicted milk production, regardless of the actual milk yield of cows, unlike numerous bST trials in which either the concentrate was supplied proportionately to the actual production or the thinnest and highest producing cows (bST-supplemented) were fed the richest diets (3, 6, 21). As a consequence, energy and protein balances were lower in the bST-supplemented groups through the winter period (Table 3, Figure 3). Furthermore, the almost complete substitution of supplemental concentrate by decreased corn silage intake (Table 3), the decrease in OM digestibility in relation to increase in DMI (Table 4), and the slightly lower protein content of the high concentrate diet (Table 1) potentially limited the bST response in the high concentrate groups. This was shown by the negative or near zero protein balance in all groups (Table 3). This hypothesis of an effect of low nutritional management is consistent with recent studies in which response to bST was higher in cows receiving diets with higher concentrate (18, 19, 26) or higher protein (9, 17) percentages. Effects of bST partly are mediated by insulin-like growth factor-I and the significant relationships established between plasma insulin-like growth factor-I and energy balance in the cows of this trial (8) confirmed the importance of nutritional status for insulin-like growth factor-I responses.

Second, body condition gain only averaged .4 point through the 30 experimental weeks and, during the grazing period, control as well as bST-supplemented primiparous cows lost body condition (Figure 4). This might reflect an insufficient feeding due to grass quality or concentrate allowance.

Third, milk yield response to bST tended to decrease in the course of treatment, but the difference in body condition between control and bST-supplemented cows increased. This decline of the response [shown by Phipps (22) but not by Bauman et al. (3)] might be due to depletion of body stores of cows or to physiological decline in the number or activity of mammary secretory cells. In this general evolution, the transitory increase in the milk yield response to bST around the start of grazing (Figure 1) could be related to the probable improvement of the nutritional status brought about by the high quality and abundance of spring grass.

Nevertheless, the similar energy intake in the high and low concentrate groups during winter suggests, contrary to the preceding arguments, that the low concentrate supply was sufficient. It has been well established that in ruminants the higher the satisfaction of nutritional needs, the higher the decrease in intake of forage fed ad libitum, as the concentrate supply increases (10). Furthermore, in several trials (14, 27, 30), increases in protein or concentrate percentage in the diet did not increase milk response to bST, probably because the nutritional needs of cows were covered or because there were other factors limiting the response to bST.

The similarities in live weight evolution during the whole experimental period in control and bST-supplemented cows disagree with the decrease in body condition in bST-supplemented cows. In a previous calibration of the scoring method used in this trial (24), one point difference in body condition score corresponded to 35 kg of live weight (of which 28 kg of lipids). The lower energy balance in bST-supplemented than in control groups during the winter period, and the higher concentration of NEFA in their plasma (8) strongly suggest that the changes in body condition score more closely reflect body reserve variations than liveweight changes, which can be partly masked by changes in the weight of digestive contents. There was, in fact, a difference in the lipid mass between control and bST-supplemented cows that was compensated for by opposite differences in body water and estimated proteins (7). Decreases in body lipids also were observed in other trials in which the same diet was offered to bST-supplemented and control cows (6, 17, 25). A greater decrease in the body condition of bST-supplemented primiparous cows was observed during the first 4 mo of bST in another trial (3). This probably is related to increased needs due to growth and better lactation persistency (Figure 1) in primiparous cows occurring simultaneously with their lower feed intake capacity. It was observed in a body composition study that protein deposition seemed to have priority over lipid deposition after the lactation peak in primiparous cows (+3.0 vs. –2.5 kg, respectively) contrary to that in multiparous cows (+1.9 vs. +33 kg, respectively) between wk 12 and 35 of lactation (R. Vérité and Y. Chilliard, unpublished results).

The mean composition of milk was only slightly changed by bST administration. The transient decrease in milk protein content in bST cows during the winter period probably was due to the decrease in energy or protein balance at that time, as shown in other short- or long-term bST trials (2, 6, 20). The slight increase in lactose content in this trial (.5 g/kg) already has been shown (5) in short-term trials (.6 g/kg in 12 studies). This trend, however, was not observed in long-term trials (3, 22), although significant [.9 g/kg, (2)] and nonsignificant [1 g/kg, (16)] increases also were reported.

The cyclic changes in milk composition agree with those found in other studies (3, 19, 22, 30). During a cycle between two injections, bST induced a significant increase in plasma NEFA at the 10th d (8, 30), at which time milk yield and milk fat content peaked. Long-chain fatty acids of milk fat, resulting in part from mammary uptake of plasma NEFA, also were shown to cycle simultaneously to milk yield (12). The decrease in protein content following the first 2 injections probably was related in part to the lower energy and protein balance induced by bST supplementation, but the situation seems to be more complicated as milk protein then increased before maximum milk response. After the sixth injection, the tendency of protein content to be higher in milk from bST-supplemented than from control cows was similar to that previously observed after several months of bST (3, 19, 22), but the reason for this remains unclear.

Digestibility of DM never was affected significantly in studies with short- or long-term administration of bST (4, 9). Improvement of feed efficiency (Table 3) was consistent with previous reports and was due both to the rise in milk yield without increase in feed intake, allowed by the mobilization of body lipids (13) and to the dilution of the maintenance requirement in total needs (3, 4).

Available data on reproduction and health problems related to bST are conflicting. In six trials with the same dose and lactation stage at the start of administration as in our study, days open and services per conception were respectively shown to increase from 93 and 1.88 in controls to 105 and 2.12 in bST-supplemented cows (23). We cannot exclude the possibility that this adverse effect of bST on reproduction was masked in our trial by the synchronization of estrus or the low response in milk yield resulting in a relatively lower decrease in nutritional balance during the first weeks of bST administration. The SCC was not affected in this study, but a recent review (28) showed that milk from bST-cows tended to have a higher SCC than that of controls in some long-term trials.

It can be concluded from this study that bST improved dairy performances without adverse effects on animal health and reproduction, at least during one lactation. However, there are some important points to consider. First, nutritional management combined or not with milk production potential probably affects milk yield response to bST, but more research is necessary to determine their respective roles. Second, it could be useful to modulate the treatment duration or dose in growing primiparous cows and to use high energy and protein diets before, during, or after bST supplementation of primiparous animals in order to allow adequate growth and replenishment of body stores for the following lactation.

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