Economics of Using Bovine Somatotropin in Dairy Cows and Potential Impact on the US Dairy Industry[1]

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ABSTRACT

Budgets with a microcomputer spreadsheet were developed to evaluate the economics of bovine somatotropin use and to estimate the impact on US dairy cow numbers. Income over feed and variable costs increased with somatotropin use and low feed prices. With high feed prices, income responses were less favorable, and when combined with low milk prices, somatotropin use resulted in less income than from control cows. Price of somatotropin did not have a major effect on production costs. The number of cows needed to meet US milk requirements is primarily influenced by per capita consumption and production per cow. With continuing yearly increases in per capita consumption of 2 kg of milk equivalent and cow milk yields of 114 kg, the number of milk cows needed through 1992 remains at the 1987 figure of approximately 10.3 million. In the scenario of a 15% increase in milk yield due to somatotropin, 20% of cows receiving the hormone, and cows receiving the hormone being 10% above the national average of all cows; the number needed in 1992 is 9.77 million, or a drop of 5.4% from 1987. Somatotropin use will have a less drastic effect on cow numbers than originally predicted.

INTRODUCTION

With the production of recombinantly derived bovine somatotropin (bST), its use to increase milk yields of dairy cows appears economically feasible. Approval must be obtained from the Food and Drug Administration before it can be used for commercial milk production. Bauman et al. (2) were the first to use recombinantly derived bST in a long-term study. Cows were injected for 188 d starting on d 84 of lactation. Increases in milk production during the injection period ranged from 23.3 to 41.2%.

Since the report by Bauman et al. (2), a large number of studies supported by four major pharmaceutical companies have been reported. In most lactation experiments, treatments started between 31 and 90 d after calving and continued until the end of lactation. Percentage increases during bST treatment usually ranged from 25 to 40 when 25 mg or more were injected daily; however, Elvinger et al. (5) obtained a 20.9 and 25.6% increase when 5.15 and 10.3 mg were injected daily. However, Palmquist (18) observed milk production increases of −.9, 5.5, and 13.4% for injections of 10.3, 20.6, and 41.2 mg/d, respectively. The energy content of the ration fed by Palmquist (18) was higher than those fed by others. Mollett et al. (12) failed to obtain an increase in milk yield with bST injections. The lack of response was attributed to high environmental temperatures; however, a more recent experiment in Florida (5) produced a response, even at low bST doses.

Most of the control cows in the bST experiments had milk yields that ranged from 21 to 31 kg milk or 3.5% FCM/d. Thus, the lactation production of the control cows ranged from 6400 to 9150 kg.

Some of the research reported changes in fat and protein percentages; however, there have been no consistent trends in either measure or in lactose percentage. No adverse effects on dairy cattle health have been reported. Some reports have indicated a decrease in reproduc-

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tive efficiency; however, Chalupa et al. (4) conclude that bST, when used at a daily dose of 25 mg or less, will not adversely affect health or reproduction. Daily injections appear to be a hindrance in adopting the technology on some dairy farms; therefore, companies have produced carriers that require biweekly or monthly injections. Biweekly injections appear to produce the same increases in milk yield as daily injections (6).

Several reports (7, 10, 11, 16) have assessed the impact of the adoption of bST technology on the US dairy industry. In all cases, the assumed adoption rates were very high (at least 80% in 5 yr).

The objectives of this study were 1) to determine through a budgeting procedure the economic returns of using bST on individual cows and 2) to assess the impact of using bST technology on the US dairy industry using various rates of adoption.

MATERIALS AND METHODS

A budgeting technique programmed on an electronic spreadsheet program (SuperCalc3, Sorcim/INS, Computer Associates International, San Jose, CA) was used for both parts of the study.

Economics of Administering Bovine Somatotropin to Individual Cows

The dairy budget described by Schmidt and Pritchard (19) was used to measure the income over feed and variable costs (IOFVC) of cows treated with bST. Variables measured were percentage increases in milk yield, milk prices, feed prices, milk yield of cows, and cost of bST. Inputs into the budgets are in Table 1. The 6000-kg production group was chosen as the approximate US milk yield per cow, 7500 kg as the approximate US DHI herd average, 9000 kg as the upper value of control cows used for bST experiments, and 10,500 kg to extend the estimates for high producing cows. The milk fat percentages, body weights, and hay equivalents consumed were arbitrarily set for the production groups.

The replacement values of heifers were obtained from the Ohio Agricultural Extension Service (17) and extrapolated for the higher production groups. Other inputs included: percent milk sold, 95; milk fat differential, \$.16 for 45.4 kg milk for each .1% change from 3.5%; marketing costs, \$.75 per 45.4 kg of milk sold; cull cow value, \$.88/kg; culling rate, 33%; value of female calf, 10% of dam's replacement value; and value of male calf, \$50. Value of calf per cow was based on the value of the male and female calves in a 50:50 ratio and a 6% calf loss.

Forage requirements were calculated from the hay equivalents shown in Table 1 and using a 50:50 ratio (DM basis) of corn silage (.51 Mcal NE_l/kg, as fed basis) and alfalfa hay (1.17 Mcal NE_l/kg, as fed basis) with a 10% wastage at the feed bunk. Grain requirements were calculated as the difference between energy requirements for milk, maintenance, and gestation (13) and those supplied by the forages and a 3% wastage at the feed bunk. The NE_l of the grain mixture was 1.7 Mcal/kg (as fed basis).

TABLE 1. Inputs into the budgets.

Item	Production groups, kg milk per cow/yr			
	6000	7500	9000	10,500
Milk fat, %	3.8	3.7	3.6	3.5
Body weight of cows, kg	630	645	660	675
Replacement value, \$	850	1150	1500	1900
Hay equivalents consumed, kg/100 kg BW	2.2	2.0	1.8	1.6
Variable costs				
Veterinary, health, \$	44	53	62	71
Breeding, testing, registration, \$	50	59	68	76
Utilities, \$	57	66	76	85
Miscellaneous and supplies, \$	42	49	56	62

The high and low feed cost scenarios from Schmidt and Pritchard (19) were used. Low feed prices consisted of hay at $60/909.1 kg, corn silage at $12.80/909.1 kg, and grain at $107.60/909.1 kg. High feed costs were $100, $30, and $230.80, respectively.

Variable costs shown in Table 1 were obtained from the Ohio Cooperative Extension Service (17) and extrapolated for the higher production groups. The veterinary, health, utilities, miscellaneous, and supply costs were increased linearly with production as the result of bST treatment. The breeding, testing, and registration costs were not increased with bST treatment. Bedding costs of $16 per cow per year were used with all production groups. Basic labor requirements for all cows, regardless of production group or increase resulting from bST treatment, were set at 60 h and $5/h. An additional 4 h were arbitrarily added to the bST treatments to account for the extra labor required for bST injections. Although the labor requirements were fixed in these budgets, they are reported as part of the variable costs. Treatment costs were calculated on the basis of a 250-d injection period with costs ranging from $.20 to $.50/d. Interest on the cow was calculated as 10% of the average of the replacement cost and cull value of the cow. Replacement costs were based on a 33% culling rate. The results are reported in terms of IOFVC, including labor. The only costs not considered are the fixed costs of building, equipment, and management fee charges.

Effect on US Dairy Cow Numbers

A spreadsheet was also used to estimate the effect of bST use on the number of dairy cows in the national dairy herd. The assumptions used for these estimates are as follows: 1) that the amount of milk needed will depend on the commercial demand for milk plus the government purchases, 2) government policy will allow the price of milk to drop to the point where the purchases by the Commodity Credit Corporation (CCC) do not exceed 2.27 billion kg of milk equivalent per year, and 3) that production per cow will continue to increase at the same rate as the last 10 yr due to better breeding, feeding, and management programs.

In order to calculate the national dairy cow needs, the US population [from USDA (20)] was projected to increase .974% per year, the average yearly increase since 1980. The commercial disappearance of milk (20) was divided by the population to determine the per capita consumption of milk equivalents and the average increase calculated per year since 1980 (2.11 kg). The US milk requirements were obtained by multiplying the population by the expected per capita consumption and adding 1.14 billion kg for milk used on the farm and 2.27 billion kg for CCC purchases.

The total US milk requirement was divided by the average projected production per cow to obtain number of cows. To determine the effect of bST usage on cow numbers needed to meet requirements, various estimates of the percentage increase in lactation milk production due to bST, percentage of cows receiving bST, and the population of cows receiving bST were made. The latter was done by using either average cows or cows that produced 10 or 20% above the national milk production average. The milk produced by the bST-treated cows was subtracted from the total milk requirement and the remaining milk required was then divided by the average production of the non bST-treated cows. This number of non-bST treated cows was added to the number of bST-treated cows to determine the total cow numbers needed to meet yearly requirements. Differences in imports and exports of milk were not considered, because the total net imports represents less than .8% of total US production (20).

RESULTS AND DISCUSSION

Economics of Using Bovine Somatotropin on Individual Cows

The IOFVC with various milk prices, milk yields per cow and bST responses, and low feed prices are given in Table 2. With $9 milk and with the lowest production group and a 10% response, bST-treated cows returned less IOFVC than non-bST cows. In all other cases, use of bST increased IOFVC over the control values. The IOFVC increased with higher milk yield per cow, increased response to bST and increased milk price. A cost of bST of $.20/cow/d was used. With $12 milk, low feed prices, and a 15% increase in milk yields, the IOFVC with bST use increased approximately

TABLE 2. Effect of bovine somatotropin (bST) on income over feed and variable costs per cow per year using low feed prices.

Milk price	Increased yield – bST	Production groups, kg milk per cow/yr			
		6000	7500	9000	10,500
($/45.4 kg)	(%)	($)			
9	Control	46	76	80	60
	10	44	89	108	102
	15	78	131	157	158
	20	113	173	206	213
10	Control	171	232	268	280
	10	182	262	315	343
	15	223	311	373	410
	20	263	361	432	477
	25	304	410	490	543
	30	344	460	548	610
11	Control	297	389	456	499
	10	320	434	522	585
	15	367	492	590	662
	20	414	549	657	740
12	Control	422	546	644	719
	10	458	606	729	826
	15	511	672	806	915
	20	564	737	883	1003
	25	617	802	960	1092
	30	670	868	1037	1181
13	Control	547	703	832	938
	10	596	779	936	1067
	15	655	852	1022	1167
	20	715	925	1109	1267

TABLE 3. Effect of bovine somatotropin (bST) on income over feed and variable costs per cow per year using high feed prices.

Milk price	Increased yield – bST	Production groups, kg milk per cow/yr			
		6000	7500	9000	10,500
($/45.4 kg)	(%)	($)			
10	Control	−246	−291	−360	−451
	10	−271	−306	−365	−447
	15	−248	−278	−332	−410
	20	−225	−250	−300	−373
	25	−202	−222	−267	−336
	30	−180	−195	−235	−300
12	Control	4	22	17	−12
	10	5	39	49	36
	15	40	83	100	94
	20	76	126	152	153
	25	111	169	203	212
	30	146	213	254	271

TABLE 4. Effect of various prices of bovine somatotropin (bST) on income over feed and variable costs per cow per year using low feed prices and a $12 milk price.

Increased yield – bST	Cost of bST	Production groups, kg milk per cow/yr			
		6000	7500	9000	10,500
(%)	($/d)	($)			
0	Control	422	546	644	719
10	.20	458	606	729	826
	.30	433	581	704	801
	.40	408	556	679	776
	.50	383	531	654	751
15	.20	511	672	806	915
	.30	486	647	781	890
	.40	461	622	756	865
	.50	436	597	731	840
20	.20	564	737	883	1003
	.30	539	712	858	978
	.40	514	687	833	953
	.50	489	662	808	928

25% for cows producing 9000 kg milk ($806 vs. $644).

When high feed prices and $10 milk prices were used, the IOFVC was negative with and without bST usage (Table 3). With $10 milk and a 10% increase in milk yield due to bST, the losses in IOFVC were greater with bST than without bST. With $12 milk, IOFVC with a 10% increase in yield due to bST was more favorable than control cows; however, the differences were very small. With the rest of the combinations, increased response to bST and increased milk production either reduced the loss of IOFVC for $10 milk or increased IOFVC for $12 milk.

The effect of cost of bST on IOFVC with low feed prices is shown in Table 4. Although the increase in bST cost decreased the IOFVC, in most cases, the IOFVC of bST-treated cows was greater than that of untreated cows.

The main effect of bST is to make cows produce like genetically superior cows (4) or a higher producing cow. Therefore, the economic response of bST-treated cows would be expected to give the same results as that of the economics of higher production. The results agree with those of Schmidt and Pritchard (19), that if it is profitable to milk cows, it is more profitable to feed and manage for higher production. The increased costs resulting from high production, including bST costs, are less than the increased returns from milk production. The exceptions in the report and in Schmidt and Pritchard (19) were with either low milk prices or high feed prices.

Effect of Bovine Somatotropin Use on the National Dairy Herd

The major limitation in estimating the impact of bST on the US cow numbers is to know the percent of cows that will receive bST. Initially some farmers will use it but find they do not have the managerial ability to care for higher producing cows. Others will wait to use the product until its economic efficacy has been demonstrated by other farmers. Previous reports (7, 10, 11, 16) used high adoption rates in their projections. These rates are probably too high initially and for at least 5 yr after its approval for use. Only 42% of US dairy farmers use a DHI testing program (14), which has been available since 1905 and demonstrated to be cost effective.

Nowak (15) conducted a survey of Wisconsin dairy farmers and concluded that 9.2% of farmers were likely to adopt the bST technology and 40.7% had an intermediate likelihood of its adoption. In a survey of 200 of the top dairy herds in California (1), results indicated that 58% of farmers would not use bST at all and 21% indicated its use on a few but not all cows in the herd. Eighty-nine percent indicated that they would not use bST if daily injections were required.

Efficacy of bST usage requires that the dairy farmer must be able to feed and manage for higher production. The national average milk yield per cow in 1987 was 6266 kg (20), whereas that of cows on all DHI testing programs was 7385 kg (21). Because artificial insemination with high genetic transmitting ability bulls has been available since the 1940s, most cows have the genetic capability to produce more milk than the national average. Many of these cows are probably fed an inadequate ration and would not respond positively to bST. Although some of these cows would be treated with bST, its use would be discontinued because of lack of response.

Considering these factors, a much more realistic estimate of the cows receiving bST would be 20 to 30% with the population of cows limited to higher producing cows. Also, it has not been determined whether cows producing 10,000 kg/yr as a result of superior genetics and management or three times a day milking would also respond to the same degree as lower producing cows, or even if dairy farmers would subject these cows to bST treatment.

With these reservations, projections were made on the number of cows required to meet the US milk requirements based on US population increases, per capita consumption, increased production per cow without bST, and various scenarios of bST usage and percentage responses. The impact of per capita consumption of milk and increased production per cow on the US cow numbers is shown in Table 5. Using 1987 as the base date for population, production per cow, and per capita consumption (20), projections on cow numbers were made for 1990, 1992, and 1994. With per capita consumption increasing 2 kg/yr and production per cow increasing 114 kg/yr (rate since 1970 has been 107.9 kg/yr), the number of cows required to meet milk production needs remains constant at about 10.3 million cows, the average number in the US in 1987 (20). The per capita increase in consumption could continue as a result of increased advertising for milk and milk products and the relatively low consumer prices for milk. The increase in production per cow will probably either remain the same or increase. With no increase in per capita consumption and a 114-kg increase in milk yield per cow per year, the number of milk cows required drops to 9.8 million in 1994, or a 5.1% decrease from 10.33 million in 1987. Increasing per capita consumption should continue to be a major goal of the dairy industry.

TABLE 5. Impact of increased per capita consumption of milk and increased production per cow on milk cow numbers needed to meet US domestic milk requirements.

Increased per capita consumption	Increased production per cow	Year 1990	1992	1994
(kg/yr)			(× 10^6)	
0	91	10.20	10.11	10.03
	114	10.10	9.94	9.80
	137	9.99	9.78	9.58
1.0	91	10.32	10.30	10.29
	114	10.21	10.13	10.06
	137	10.10	9.96	9.83
2.0	91	10.43	10.49	10.55
	114	10.32	10.31	10.31
	137	10.22	10.14	10.08

The cow numbers required to meet US milk needs with various bST scenarios are shown in Table 6. It is assumed that bST approval would occur in 1990 and that by 1992 the number of dairy cows using bST would be stable. One of the more likely scenarios would be a 15% increase in lactation milk yield due to bST, using a population of cows that were 110% of US average (7518 vs. 6835 kg), and having 20% of the cows receiving bST. In this case with a 2-kg increase in per capita consumption per year, 9.77 million cows would be required in 1992, a drop of 5.4% from 1987. In comparison, the number of milk cows from 1982 to 1987 dropped from 11.01 million to 10.33 million, a drop of 6.2% (20).

Lower per capita consumption, increased percent of cows receiving bST, and use of bST on the higher producing cows lower the number of cows required (Table 6). The lowest number of cows was reached with the scenario of no increase in per capita milk consumption,

TABLE 6. Cows needed to meet US domestic milk requirements in 1992 with use of somatotropin (bST) under varying conditions and assuming that milk yield of untreated cows will increase 114 kg/yr.

bST			Per capita increase in milk consumption, kg/yr		
Increased yield	Population of cows[1]	Percent of cows	0	1	2
(%)			(X 10^6)		
0	0	0	9.94	10.13	10.31
10	100	20	9.74	9.92	10.11
		30	9.64	9.82	10.00
		50	9.44	9.62	9.80
		100	8.95	9.11	9.28
	110	20	9.52	9.70	9.88
		30	9.31	9.49	9.66
		40	9.10	9.28	9.45
	120	20	9.30	9.48	9.65
15	100	20	9.64	9.82	10.00
		30	9.49	9.67	9.85
		50	9.19	9.37	9.54
		100	8.45	8.61	8.77
	110	20	9.41	9.59	9.77
		30	9.15	9.32	9.49
		40	8.89	9.05	9.22
	120	20	9.18	9.36	9.53
20	100	20	9.54	9.72	9.90
		30	9.34	9.52	9.69
		50	8.95	9.11	9.28
		100	7.95	8.10	8.25
	110	20	9.30	9.48	9.65
		30	8.99	9.15	9.32
		40	8.67	8.83	8.99
	120	20	9.06	9.24	9.41

[1]Percentage milk yield of cows receiving bST. In 1992, average production is 6836 kg, thus, 110 = 7519.6 and 120 = 8203.2 kg.

a 20% increase in lactation milk yield due to bST, and 100% of cows receiving bST. In this case, 7.95 million cows are required in 1992, or a 23% reduction in numbers from 1987.

Not all combinations of variations in Table 6 were used. If 100% of cows are used, the average milk yield of the population can only be used. Likewise, only about 20% of the population of cows would average 120% of national production. With all scenarios of 20 to 30% of cows receiving bST, the required cow numbers ranged from 9.32 to 10.11 million with a 2 kg/yr increase in consumption and from 9.15 to 9.92 million with a 1 kg/yr increase in consumption. In these cases, the largest drop would be 11.4% in comparison to 1987.

The regional impact of adopting bST was not considered but has previously been addressed by a number of workers (3, 7, 22). The question of herd size was also not considered; however, Kalter and Milligan (9) addressed this question and stated that bST technology was herd size neutral because no capital investments are required to adopt the technology. However, they also stated that herd size may be a determinant because of the positive relationship between herd size and profitability. They also suggest that the attainment of higher milk yields may require capital investments that are not herd size neutral, such as environmental controls, more sophisticated feeding systems, and computerized information systems.

Several questions remain to be answered about commercial use of bST. The effects of using bST for two lactations have been reported (6, 8); however, it is important to know bST effect for three or more lactations. A second question is the long-term effect on first lactation cows. These animals appear to respond the same as older cows, but will they be able to make the necessary growth during the first lactation? The third question relates to the effect on very high producing cows. Cows producing around 9000 kg per lactation respond to bST, but is the effect the same on cows producing 10,000 kg or higher?

CONCLUSIONS

Although it is impossible to predict the number of cows that will receive bST once it is approved or the percentage increase on commercial farms, the budgeting results indicate that bST use will be an economical alternative for dairy farmers who have the ability to feed and manage higher producing cows. Without increased feed intake, bST use will not be beneficial. Low milk prices and high feed prices will not be conducive to using bST. Previous estimates of number of cows that will be put on bST are probably too high; therefore, lower projections were used. Reductions in cow numbers will occur with bST usage, but the number is not alarming. Much of the decrease in cow numbers required can be arrested by continuing the increase in per capita consumption of milk and milk products.

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