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Bovine Somatotropin and Its Economic Implications

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Bovine somatotropin (BST) has been heralded as a means of increasing production efficiency on dairy farms. While BST use on the nation's dairy farms has not yet received approval from the Food and Drug Administration (FDA), approval is expected by 1990. How will dairy farmers and consumers of dairy products be affected by this product? The answer has not fully been determined, but a considerable amount of information about BST is available. This article discusses BST and evaluates some economic implications for the dairy farmer.

What Is BST?

Bovine somatotropin is a naturally occurring protein hormone that is produced by the pituitary glands of cattle. Scientists have known for more than 50 years that supplementing the BST of lactating dairy cows will increase milk production. General use has been limited, however, because of the difficulty of obtaining this material.

A process of producing BST artificially has been developed using biotechnology. This technology allows mass production of BST in commercial quantities at a low cost. The gene responsible for producing BST in cattle has been isolated and can be transferred to bacteria cells. The bacteria then are used to produce BST.

Effect of BST on Dairy Cows

Supplemental BST is administered to cows by injection. At first it was given daily, but recent research has shown that slow release injections can be given at intervals of up to 2 weeks. Cow response to BST appears to be similar for either daily and less frequent injections. Supplemental BST dramatically increases milk production, but the process is not a free lunch. More milk requires more feed, primarily concentrates, with or without BST.

Cows usually respond to BST by increasing production within a few days, but they may not increase dry matter intake for 4 or 5 weeks. This delay between the cow's increased demand for energy and increased intake will present management challenges for dairy producers. Closer attention to body condition scores, feeding programs, herd health plans and reproduction management will be necessary. For example, high energy diets must be fed and BST treatment may need to be delayed until after cows are pregnant.

BST and Milk Quality

All milk contains measurable amounts of BST, since it is a naturally occurring protein hormone. No difference in the trace amounts of BST has been observed in milk from cows that have received clinical doses of BST and those that have not.

The FDA has concluded that milk from BST-treated cows is safe for human consumption. Data show that BST is not biologically active in humans because it is a protein that is digested when consumed. The FDA has authorized a "zero withdrawal time" to market milk or meat from cows treated with BST. This means that no time need elapse between treatment of a cow with BST and sale of her milk or meat. Research is underway to evaluate the effect BST has on cow health over several lactations of use.

Predicted Impact of BST On Milk Production, Feed Efficiency and Profit

Much of the information written about the impact of BST on the dairy industry is based on maximum responses that have been observed in research trials. The fact is that milk response to BST treatment has been inconsistent, the increase varying from 5 to 40 percent in university trials. Responses of 15 to 20 percent per cow are more likely in a commercial dairy setting. Responses will occur only during mid and late lactation when cows are treated with BST. Treating cows with BST during early lactation will increase the incidence of metabolic disorders and other health problems that are common in high-producing cows after calving.

The authors have developed a model to predict the consequences of treating dairy cows with BST. We believe that these predictions are more realistic for the commercial dairy than those based on maximum responses. Predicted lactational responses to BST treatment for cows producing 16,000 or 20,000 pounds per year are described in this paper. These are expected typical results with good management practices. Responses on individual dairy farms may vary substantially depending on conditions.

Assumptions and Calculations For Cows Treated with BST

The model assumes a 365-day lactation cycle (305 days milking, plus 60 days dry), and is based on changes that occur during the normal lactation cycle of mature cows.

For example, estimated monthly milk yields, milk fat tests, body weights and intakes of dry matter for a cow producing 16,000 pounds of 3.5 percent fat-corrected milk (FCM) are shown in Table 1.

Monthly milk yields and intakes were also estimated for cows producing 20,000 pounds of FCM annually. Monthly milk fat tests and body weights were held constant across production levels. Feed requirements for production and body maintenance were calculated for each level of production.

The model also assumes that cows of all genetic abilities will respond to BST treatment by producing more milk. We hypothesize that BST treatment will boost milk production by 15 percent during the first month of treatment and 20 percent during subsequent months. Thus, milk production for the entire lactation will be increased by 14.6 percent. We also assume that the response will be proportional to a cow's pretreatment production. In other words, a 15 percent response will be 9 pounds for a cow producing 60 pounds of milk per day and 12 pounds for a cow producing 80 pounds of milk.

In the model, treatment with BST begins 90 days after calving and continues to the end of the 305-day lactation period, making a 215-day treatment period. Other assumptions are that the milk fat test is not affected by BST treatment and that BST treatments do not cause a delay in getting cows rebred, so the length of the lactation cycle is not affected. Fig. 1 shows the difference in production and body weight between BST-treated and untreated cows during a 305-day lactation. Note that increased production continues from beginning of BST use until the end of the lactation.

Dry matter intake of treated cows was calculated in the same way as that for cows not treated with BST. Higher intake values for treated cows reflect treatment effects on milk production and body weight. All cows lose body weight immediately after calving. We assume that cows with BST will begin to regain weight 1 month later than untreated cows. We also assume that once cows begin to regain weight, rate of gain will be the same for treated and untreated cows. Consequently, BST-treated cows will weigh 50 pounds less than untreated cows when dried off, so they will need extra energy during the dry period in order to weigh the same as untreated cows when they calve again.

Predictions from the Estimation Model

Predicted responses in annual yield of 3.5 percent FCM to BST treatment are shown in Table 2. Cows capable of producing 16,000 pounds of 3.5 percent FCM per year without BST are predicted to increase their annual milk yield by 2,339 pounds. Likewise, a milk response of 2,924 pounds is forecast for cows capable of producing 20,000 pounds of 3.5 percent FCM per year without BST. Average daily milk production would increase by 10.9 to 13.6 pounds, depending on the production level, during the 215-day treatment period.

Nutrient requirements from NRC tables and our estimated dry matter intakes were used to formulate diets for the cows in our examples. The amounts of alfalfa hay, cereal grain and protein supplement needed annually were then calculated. All diets contained high quality alfalfa hay as the only forage. Annual feed requirements shown in Table 3 are expressed on a 90 percent dry matter basis and 7 percent feed waste.

Data in Table 3 illustrate how the quantity of feed required per cow increases as milk yield per cow increases. Proportions of ingredients in the diet also are affected by level of milk production. A greater proportion of concentrates to forage and more protein supplement in the concentrate portion of the diet are necessary to support increased levels of milk production. A greater annual requirement for feed with an increased density of nutrients will result in a greater annual cost for feed. It will cost more to feed cows treated with BST than untreated cows.

Table 4 illustrates the effects of the level of milk production and BST treatment on the efficiency of converting dietary energy into milk. Intakes of dietary energy (net energy for lactation) are for the entire year, including the dry period. The general relationship is that conversion efficiency improves with increased production per cow regardless of cause. This is because a smaller proportion of the energy consumed by the cow is needed for maintenance so a greater proportion is available for production.

Economic Benefits From BST Use

The impact of BST treatment on dollar return can be illustrated using a hypothetical example (Table 5). Two levels of feed prices were used in the analysis and milk value over costs of feed and BST were estimated for each level. The lower level of prices was called "normal" feed prices, and the upper level was designated as "high" feed prices. As feed prices change, so will the relative benefits of BST. The higher the feed costs relative to milk value, the lower will be the benefits of using BST. Returns above feed costs are shown for two levels of production with and without BST use.

Dollar values used in this report are for establishing relationships, rather than depicting specific profit margins. Circumstances change over time within a dairy, and no two dairies are exactly alike. Further, response to BST by individual cows will vary substantially. Because the pharmaceutical companies have not yet announced what they will charge for BST, a cost of 50 cents per cow per day of treatment, a total of $108 per year, is assumed in our examples.

When prices are constant, milk value and feed cost both increase with BST use. Economic benefits result when the value of milk increases by more than the cost of added feed and the BST treatment. For example, Table 5 assumes a constant milk price of $11.50 per cwt and two levels of feed prices. A cow producing 16,000 pounds of milk per year is assumed to increase production to 18,339 pounds after BST treatment. Milk value over feed cost would be $1,225 before BST use and $1,339 after using lower feed prices. Milk value increased by $269, and added feed and BST cost totaled $155, resulting in a net gain of $114. With higher feed prices, the estimated added cost was $172, and the increase in milk value over feed and BST was $97 per cow. A greater difference was evident for the cow producing 20,000 pounds of milk.

Economic gains from BST use for two production levels, two feed price levels and three milk prices are shown in Table 6. The production levels before BST use are 16,000 and 20,000 pounds per year, the feed levels are normal and high, and the milk prices are $9.50, $10.50 and $11.50 per cwt. Note that these results apply only for the assumptions made. For the cow producing 16,000 pounds, a milk price of $11.50 per cwt and normal feed prices, BST use increased milk value above feed and BST costs by $114. An increase of $97 per year was estimated using higher feed prices. Lower milk prices reduced milk values and also reduced the economic benefit of using BST.

Estimated gains from BST for a cow producing 20,000 pounds of milk before BST use were $154, $125 and $96 for the same three milk price levels. Economic gains were higher for the cow producing 20,000 pounds per year than for the cow producing 16,000 pounds.

These relationships are shown in Fig. 2. Value of milk over estimated feed and BST costs are shown for two levels of feed prices with and without BST. At all milk prices and at normal and high feed costs, BST users receive higher economic returns

Table 1. Monthly production and estimated feed intake of a cow producing 16,000 pounds of 3.5 percent FCM.

Month	Daily milk	Milk fat	Body weight	Daily DM intake
1	61.0	3.8	400	41.4
2	70.9	3.6	1,300	45.1
3	69.5	3.3	1,300	46.2
4	64.2	3.3	1,350	45.6
5	57.0	3.4	1,350	43.8
6	51.0	3.5	1,400	43.3
7	46.0	3.5	1,400	41.8
8	41.0	3.6	1,450	41.5
9	35.9	3.7	1,450	40.1
10	30.0	3.7	1,500	39.3
11	—	—	1,500	28.5
12	—	—	1,550	29.5

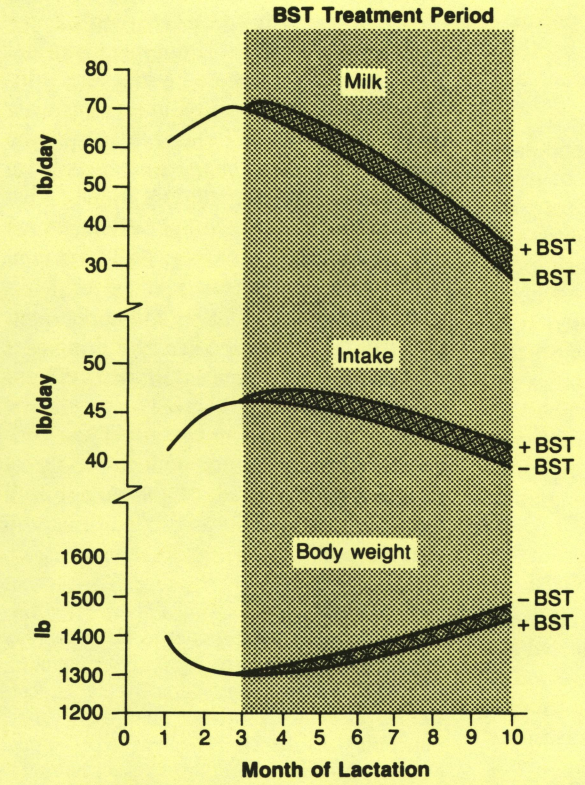

Fig. 1. The effect of BST on milk production, dry matter intake and body weight change during lactation.

Table 2. Effect of BST on milk production of a cow producing 16,000 or 20,000 pounds of 3.5 percent FCM.

Annual milk		Milk response	
without BST	with BST	per year	per day treated
(lb)	(lb)	(lb)	(lb)
16,000	18,339	2,339	10.9
20,000	22,924	2,924	13.6

A 215-day treatment period.

Table 3. Annual feed requirements related to production level and BST use.

3.5 percent FCM production	Alfalfa hay	Cereal grain	Protein supplement	Total feed
(lb)	(lb)	(lb)	(lb)	(lb)
16,000	12,381	5,087	190	17,658
18,339 (BST)	12,263	6,029	260	18,552
20,000	11,245	6,827	824	18,896
22,924 (BST)	10,997	8,020	1,035	20,052

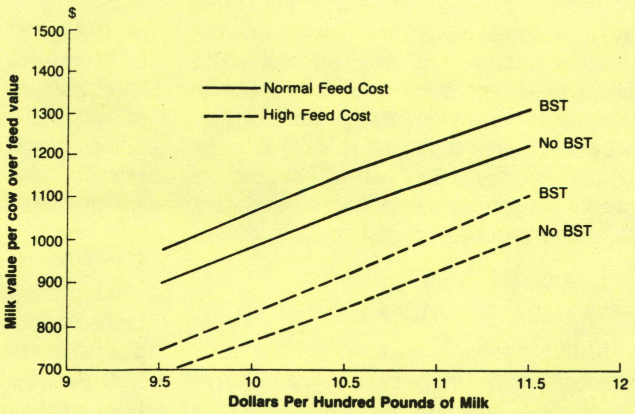

Fig. 2. Milk value over feed cost for a dairy cow producing 16,000 pounds without BST or 18,339 pounds with supplemental BST at specified milk prices.

Table 4. Feed efficiency related to production level and BST use.

3.5 percent FCM production	Annual NE (lact) intake	Conversion efficiency	Energy for production
(lb)	(Mcal)	(FCM/Mcal)	(%)
16,000	11,843	1.35	55
18,339 (BST)	12,644	1.45	58
20,000	13,215	1.51	60
22,924 (BST)	14,274	1.61	64

Table 5. Estimated value of milk over feed and BST costs at normal and high feed prices.

3.5 percent FCM production	Total milk value[1]	Feed cost[2] Normal	High	BST	Value over feed and BST costs Normal	High
(lb)	($)	($)	($)	($)	($)	($)
16,000	1,840	615	833	—	1,225	1,007
18,339 (BST)	2,109	662	897	108	1,339	1,104
20,000	2,300	747	1,000	—	1,553	1,300
22,924 (BST)	2,636	821	1,097	108	1,707	1,431

[1]Milk price $11.50/cwt.

[2]Feed cost ($/ton) — Normal: alfalfa hay, $60; cereal grain, $85; protein supplement, $290; High: alfalfa hay, $80; cereal grain, $120; protein supplement, $340.

Table 6. Estimated value of milk over feed and BST costs for two production levels and three milk prices.

	Milk price $11.50	$ per cwt $10.50	3.5% FCM $9.50
Normal feed prices[1]			
Production			
16,000	$1,225	$1,065	$ 905
18,339 (BST)	1,339	1,156	972
Increase	114	91	67
20,000	1,553	1,353	1,153
22,924 (BST)	1,707	1,478	1,249
Increase	154	125	96
High feed prices[1]			
Production			
16,000	1,007	847	687
18,339 (BST)	1,104	921	738
Increase	97	74	51
20,000	1,300	1,100	900
22,924 (BST)	1,431	1,202	973
Increase	131	102	73

[1]Feed cost ($/ton) — Normal: Alfalfa hay, $60; cereal grain, $85; protein supplement, $290; High: Alfalfa hay, $80; cereal grain, $120; protein supplement, $340.

over estimated costs than non-users. Actual production responses on individual farms may vary from those in this example due to management and other differences. Whether a particular dairy farmer will benefit from BST use will depend on production responses on that farm relative to added costs associated with its use.

Impact of BST on Milk Production and Price

Milk production per cow has increased nearly threefold in the past 50 years. Many innovations and improved practices have been adopted by dairy farmers during that period. Bovine somatotropin is another innovation that is expected to enhance milk production. Unlike many new practices, BST can increase productivity in a short time and will require little investment.

Once a practice has been proven effective, those who adopt early are usually the ones who gain the most. Later adopters are often forced to accept a new practice just to stay in business. We cannot know how quickly BST will be adopted by dairy farmers when it receives final FDA approval. Acceptance could be fairly rapid because of the low investment cost associated with its use. Dairymen with high production per cow will likely be early adopters of BST and will probably gain the most in the long run.

One concern with BST use is the effect that it may have on the total milk supply. The United States has recently experienced a period of milk surplus and high costs to the Commodity Credit Corporation (CCC). Under the milk price support program, the CCC purchases and removes from the market sufficient quantities of dairy products so that the remaining supply can be sold on the market at or near the support level. The Food Security Act of 1985 reduces the milk price support each year that the amount purchased by the CCC is expected to exceed 5 billion pounds of milk equivalent. If milk production becomes excessive because of BST use, the support price and, consequently, the market price would be reduced.

Production Controls

Supply and demand working together establish prices in a free market. When supplies increase relative to demand, prices fall. Because producers cannot effectively control supply of milk, the price support program was adopted to prevent drastic price reductions during periods of increased production. Combining production controls with farm quotas is another method of limiting supplies to maintain prices.

Supply management, while unpopular, is a means of regulating supplies of milk and to reduce or eliminate government purchases through the CCC. If BST is approved and milk supplies increase as a result, either the support price will need to be reduced or production restricted. Fewer cows would be needed to supply the market. This would mean fewer cows on existing farms or a reduced number of dairy farms in the nation. Supply management may be necessary if existing programs are unsuccessful in restricting milk supplies.

Summary and Conclusions

Bovine somatotropin is a protein hormone that occurs naturally in cattle and affects the ability of cows to produce milk. Genetic engineering has made it possible to produce BST commercially. This product can be used to supplement the cow's natural ability to produce milk, substantially increasing production and efficiency.

This publication discusses an economic analysis of BST use on dairy cows. The analysis assumed that milk production increased by 14.6 percent for a 305-day lactation when BST was used during the last 7 months of the lactation. Increased expenses included the cost of BST injections and the cost of more high energy feed needed by the higher producing cows. Economic returns over feed and BST costs were estimated for two production levels, two levels of feed cost and three different milk prices. In each case economic returns were higher with BST use than without it.

Dairy farmers who begin using BST early and those who have superior management skills will probably realize an increase in net returns. Poor managers and non-adopters may see a decline in net incomes and eventually may terminate production. These changes could be delayed by a supply management program that would limit the amount of milk that could be marketed. Supply management may be necessary if excess production continues to be a problem.

The use of BST will not affect the quality of milk. Prices received by producers will be affected to the extent that BST increases the total milk supply. Benefits of BST to the average farmer could be eliminated by a milk price reduction. Dairy producers who can adjust and change with technology and economic conditions will survive and profit.

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