Staff Paper

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Key Words: bovine somatotropin, dairy, net farm income

Abstract:

Bovine somatoropin (bST) alters total milk production and production patterns in dairy cows and understanding the economic benefits of bST for the dairy producer are critical. Holstein cows (n = 555) from four Michigan dairy farms were randomly assigned as untreated controls or to receive 500 mg of bovine somatotropin (Posilac^{R}) administered every 14 days beginning at 63 to 69 days of lactation and continuing until approximately 21 days prior to the end of lactation or until the animal was removed from the herd. Average peak milk production was 50.8 kg / day and occurred at an average of 113 9 days of lactation for bST-treated cows while average peak production was 48.9 kg / day occurring at an average of 86.4 days of lactation for control cows; both parameters were significantly greater for bST-treated cows compared to controls. Study cows treated with bST were significantly more persistent in lactation (7% greater lactational persistency) compared to control cows. All DHIA estimates and actual milk produced were not significantly different between the study treatment groups for any of the four comparisons made (first, second, third monthly tests after bST treatment initiation and final (305-day) DHIA production estimates); however, the accuracy of DHIA production estimates was significantly affect by the amount of time elapsed since bST but became non-significant by the third DHIA test date. The use of bST changed NFI for each of the four study farms by $96.21, $3.57, $78.71 and ($7.15) per bST-treated cow, respectively during the trial period (from 63 to 305 days of lactation). The overall average change in NFI attributable to bST was $43.01 per bST-treated cow.

Profitability of bST use was observed to be quite variable between farms studied because many factors were found to affect the change in NFI per cow resulting from bST use; the level of production response and the price received for milk had the largest effects on the change in NFI associated with bST use; by contrast, price paid for bST itself and feed had only minimal effects on bST-associated profitability. Diseases that may be associated with bST may reduce the profitability of this product and need to be considered as a cost of bST use if present.

Introduction:

It has been stated that bovine somatotropin is the most widely studied product that has ever been approved for use in dairy cattle. However, most pre-approval studies were focused primarily on the two areas that the US Food and Drug Administration (FDA) requires be researched prior to approval: animal safety and product efficacy. While these are important features that needed to be thoroughly studied other factors related to a products use, such as the economic effect of the product, are not required by the FDA for approval. The economic aspects of the products use are left to be determined by the market itself; the resulting "trial and error" system whereby producers perceptions of profitability resulting from the products determine how widely a product is used and how rapidly it is adopted. This method of "testing" the economic viability of a product is less than optimal; however, without research aimed at addressing the economic efficiency of new products, this is the only way producers can attempt to determine how well a particular product "works" on their operation. In the absence of research conducted expressly for the purpose of determining the economic impact of the new product, estimates are made from data generated in preapproval studies (that were focused on animal safety and/or product efficacy). Economic estimates made in this fashion may be inaccurate because they are based on data that were not designed to address economic issues, and few of these studies are conducted in commercial-type dairy situations.

Another feature that has been largely ignored by preapproval studies is the influence that bST may have on Dairy Herd Improvement Association (DHIA) milk production projections. The DHIA believes that no significant bias is introduced into lactational milk projections by the use of bST. However, bST can alter the shape of the lactation curve for most cows because peak milk production as well as lacational persistency are both altered by bST.[1] Additionally, the currently available bST product (Posilac[R,a]) is a 14-day sustained release preparation which produces variable effects on milk production response through the 14-day injection cycle. This is because milk production gradually increases after bST administration and peaks on approximately day 8 to 9 post-injection. Production then declines to near pre-treatment levels by approximately day 12 to 13 post-treatment. Therefore, because DHIA milk production projections are often made based on a single days or milkings production once each month, which day during the 14-day bST injection milk production is measured may significantly affect milk production estimates. Based on these potential sources of variation, it has been suggested that new lactation curves and milk production prediction equations need to be constructed for bST-treated cows.[2] This is important because managers use DHIA milk projections to support culling decisions; DHIA recommends that cows with projected 305-day Mature Equivalent milk production of 2,000 less than herdmates are good candidates for culling because of low milk production.[3] This is because bST has the ability to cause cows of lower genetic merit for milk production to more closely resemble cows with high potential for production[1]. However, if currently used DHIA milk projections cannot accurately predict the increased ability of cows to produce milk, cows may be culled (based on faulty milk projections) that otherwise would be retained (profitably) in the herd.

Most estimates of increased profitability from bST use have been made using data derived from preapproval trials that were performed in research-type herds and often did not use the commercially available bST (Posilac^R) product.[4] If Posilac^R was used, it often was not used according to the products currently labeled directions. Also, most estimates of increased profit resulting from bST use have largely ignored any negative financial impacts that may result from the products use; these estimates often only account for the cost of bST and additional feed consumed as a result of the products use. If any negative financial effects are associated with bST, these need to be subtracted from any increased revenue in order to accurately estimate the products true financial impact on the farm. Of primary concern is any influence bST may have on clinical mastitis incidence, which has been observed to increase concurrently with increased milk production.[5] Additionally, concern for bST use involves possible increased incidence of diseases which may decrease reproductive performance.[6,7] Such financial losses, if associated with bST usage, must be subtracted from increased revenues

Additionally, it has been stated that actual increases in milk production in commercial herds may be as much as 25% less than was observed in preapproval trials.[8] Milk production response to bST administration has been observed to vary from up to 10 kg/day to nearly no response at all.[9,10] Therefore, to accurately calculate production changes and any resulting influence on farm profitability, the use of daily individual-cow milk weights must be used to compare similar groups of bST-treated and untreated (comparable) herdmates.

Clinical Report: Materials and Methods

Selection of farms and cows

Holstein cows (n = 555) from four Michigan dairy farms were randomly assigned as untreated controls or to receive 500 mg of bovine somatotropin (Posilac^{R}) administered every 14 days beginning at 63 to 69 days of lactation and continuing until approximately 21 days prior to the end of lactation or until the animal was removed from the herd. Three Michigan commercial dairy farms and one university demonstration dairy herd participated in this study. Herd sizes were approximately 600, 250, 250, and 120 milking cows. As part of the broader study, farms were selected on the following criteria: 1) mean bulk tank somatic cell count < 300,000 cells/ml during the 12 months prior to the study, 2) a mastitis control program including postmilking teat dip and dry cow treatment of all cows, 3) a standardized course of therapy for clinical diseases, 4) enrollment in the Michigan Dairy Herd Improvement Association, 5) availability of a computer system for recording cow events and daily, individual-cow milk weights, and 6) a willingness to comply with the experimental protocol.

All cows in this study calved during a period of approximately six months between June 27, 1994 and January 24, 1995. Therefore, the study sample consisted of approximately 50% of the cow population on each farm. As each cow attained the ninth week of lactation, they were assigned to receive 500 mg of bST administered at 14 day intervals or were assigned to a control group that did not receive any injections. Alternate week assignment was used for three farms with all cows calving during a given week assigned to the bST-treated group and all cows calving the next week assigned to the control group. The remaining farm assigned treatments at calving on an alternate cow basis. In all herds, bST was administered by herd personnel. As specified by bST label directions, cows were excluded from the study if they were in poor health, as assessed by the herd managers at the ninth week of lactation. This exclusion criterion was applied equally to both the control and bST treatment groups and the reasons for exclusion did not differ between the study groups. Therefore, this analysis included only cows that attained at least the ninth week of lactation.Care and management of cows

All farms housed lactating cows in free stalls, milked all cows three times per day and fed a total mixed ration balanced to meet the nutritional requirements of each cow's current milk production. Herdsmen diagnosed, treated and reported cases of disease when they were knowledgeable and confident of the underlying disease process and capable of administering appropriate treatment; otherwise, diseases were diagnosed and treated by a veterinary practitioner. Records were maintained electronically (DairyComp 305[R,b]) by all study farms. Data stored included daily, individual-cow milk weights, disease and reproductive events, as well as dates and reasons for death or culling.

Management of data and statistical analysis

The SAS System for Windows[R,c] was used for all statistical analysis and Excel[R,d] was used to manage the data. All milk production measurement variables (production and day of lactation comparisons) were compared between bST-treated cows and controls by Student's t-test. Lactational persistency (rate of decline in daily milk production) was calculated by finding the average milk production within each complete 14-day bST injection period and then dividing average production for each of these 17 injection cycles by the average of the first (baseline) injection cycle.[11] The persistency for each injection cycle and for all 17 injection cycles averaged together was then calculated for primiparous, multiparous and all study cows and then compared between bST-treated and control cows. A repeated measures ANOVA was used to model the difference in production between actual milk produced (measured by daily, individual-cow milk weights) and DHIA estimated lactation production. The difference in production between these two measures was used as the repeated (dependent) variable and dummy variables for herd effect were included in the model. Person's correlation coefficient was used to analyze the correlation between DHIA milk estimates and actual milk produced. The calculated correlation coefficients were then compared between the study treatment groups by use of a test statistic which utilized a Fisher z transformation.[12]

Economic analysis

The principle financial measure of interest in this study was the change in Net Farm Income (NFI) resulting from bST usage. This parameter was chosen because it best captures the expected change in farm profitability resulting from a management change (in this case using bST) and conforms to the recommendations put forth by the Farm Financial Standards Council.[13] The partial budget method[14] was used to calculate the change in NFI for each study farm (separately for primiparous and multiparous cows) and the entire study population using only those costs that changed as a result of bST use. The partial budgets used in this analysis were based on the template constructed by Willett et al.[15] Using the results of these partial budgets, a break-even milk price was calculated for each group and farm in this study. A sensitivity analysis was also performed to examine the effect on NFI resulting from fluctuations in certain variables (e.g., changes in milk production, milk and bST price as well as feed price).

Clinical Report: Results of the Study

Changes in milk production patterns and the effect on DHIA estimates

Because cows were randomly assigned to study treatment group, milk production in the pretreatment (the first 63 days of lactation and prior to bST treatment) period should (theoretically) have been fairly balanced between the study treatment groups (Table 1). However, production in the pretreatment period differed significantly for one study farm (Farm three) with control group cows producing 192.2 kg more milk in the pretreatment period compared to bST-treated cows ($P = 0.03$). In the remaining three herds, no significant difference in pretreatment milk production was found between the study groups. For all study cows, pretreatment milk production was similar between the study groups with only a 47.1 kg difference observed ($P = 0.34$).

Average peak milk production was 50.8 kg / day and occurred at an average of 113.9 days of lactation for bST-treated cows while average peak production was 48.9 kg / day occurring at an average of 86.4 days of lactation for control cows (Table 2). Both average peak milk production and average time to peak production were significantly greater for bST-treated cows compared to controls ($P = 0.01$ and $P < 0.0001$, respectively). While average peak production was not greatly different between bST-treated and control multiparous cows ($P = 0.09$), bST-treated primiparous cows had higher average peak milk production when compared to similarly aged controls ($P < 0.0001$). Study cows treated with bST were significantly more persistent in lactation (7% greater lactational persistency) compared to control cows (P < 0.0001).

Actual milk produced and all DHIA production estimates analyzed were found to be significantly correlated (P < 0.001) when compared by Pearson correlation analysis (Table 3). However, correlation coefficients for all DHIA estimates and actual milk produced were not significantly different between the study treatment groups for any of the four comparisons made (first, second, third monthly tests after bST treatment initiation and final (305-day) DHIA production estimates).

While correlations were not different, the accuracy of DHIA production estimates was significantly affect by the amount of time elapsed since bST initiation (Table 4). Milk production at the first DHIA test date after bST initiation underestimated actual production by 4.7% for bST-treated cows and by 0.8% for controls yielding a 3.9% difference in accuracy (P = 0.001). Similarly, DHIA underestimated production by 2.7% for bST-treated cows and overestimated production by 0.1% for control cows (2.8% absolute difference) at the second test date after bST initiation (P = 0.002). However, the difference in accuracy (0.3% absolute difference) was not significant by the third DHIA test date (P = 0.19). Therefore, by the 305th day of lactation (final DHIA estimate), DHIA overestimated actual production by 2.4% for both the bST-treated and control groups, and accuracy had improved to the point that no significant difference existed between the study treatment groups (P = 0.68).

A repeated measures ANOVA model was constructed to analyze the effect of bST on DHIA lactation milk estimates. In this model, the repeated measure (dependent variable) was the difference between the actual milk produced during lactation (as measured by daily, individual-cow milk weights) and the DHIA estimates made at approximately 30, 60 and 90 days after bST initiation and the final (305-day) estimate. The dependent variables of study farm and treatment group were included in this model. The difference in production between actual and estimated production was analyzed by orthogonally contrasting this difference at the first three time frames (30, 60 and 90 days after bST initiation) with the difference at the final (305-day) estimate. The results of this analysis confirmed the bivariate comparison because the variable for bST treatment effect was significant ($P < 0.001$) at the first two time periods but was not significant by the third time frame ($P < 0.091$).

Economic analysis

Calculation of the change in NFI attributable to bST use was made considering cost of the bST product, labor to administer injections and additional feed required to support extra milk produced. The use of bST changed NFI for each of the four study farms by $96.21, $3.57, $78.71 and ($7.15) per bST-treated cow, respectively during the trial period (from 63 to 305 days of lactation). The overall average change in NFI attributable to bST was $43.01 per bST-treated cow during the trial period. A large variation in NFI gain was found among the four farms studied (Table 5). An increase in NFI of $96.21 for the trial period was observed on one study farm while another farm experienced a $7.15 loss resulting from bST use during this time frame. Because bST-treated primiparous cows experienced an approximately 27% greater production response to bST compared with multiparous cows, the younger cows returned a two-fold greater increase in NFI for the trial period compared with older cows (Table 6).

When break-even milk price was calculated, a response of 2.3 kg per bST-treated cow per day was necessary to cover additional costs incurred from bST use (increased cost due to the bST product as well as administration (labor) and additional feed costs). Therefore, any greater production response would be profitable when only these direct costs were attributed to bST use. For the observed level of production response (2.9 kg per bST-treated cow per day), a break-even milk price of $21.86 / 100 kg of milk was calculated. Because of the greater production response observed for primiparous cows compared to multiparous cows, in these young cows bST use was profitable at approximately $2.89 / 100 kg of milk production below the all-cow break-even price.

A sensitivity analysis found that milk price and bST production response both had profound effects on the change in NFI per bST-treated cow. A small (5%) increase in production response increased NFI by 14.5% but a doubling of this value (to 10% increased production response) increased NFI by 25.3%, which was less than the expected 29.0% increase. When milk price dropped by 10%, the change in NFI decreased dramatically (by 45.1%) with a proportional decrease when milk price fell by 20%. However, compared to production response and milk price, profitability was only slightly sensitive to the price of bST and feed. A decrease in bST price of 5% increased the change in NFI by only 10.3% while a 5% difference in feed price altered the change in NFI by just slightly over 4%. The relative financial impact of a change in bST response or price, feed cost or milk price was accessed by dividing the percent change in the dependent variable (change in NFI) by the percent change in the independent variable (change in bST response, bST product price or feed costs). Change in milk price was found to have a proportional effect on NFI (NFI fell by a similar amount when milk price was decreased by 10% to 20%) whereas bST production response and product price did not proportionally affect the change in NFI (the relative affect on the change in NFI was not as great when response or feed price was changed from 5% to 10%).

Discussion:

Field trials are susceptible to underreporting bias because of potential deficiencies in the recording of animal health events on the farm. Previous researchers have identified this source of error and the variation in study protocol compliance regarding health data recording that exists among farms.[16] The herds reported here all had disease recording systems in place prior to the start of this trial; this assisted in the accurate recording of disease events, subsequent treatment and periods of discarded milk.

Twenty-two cows that were originally selected for this trial were in poor health at the time when bST treatment was to begin and therefore were excluded from the study. This exclusion was in accordance with the bST products label that states cows must be determined to be healthy if bST treatment is to begin during the ninth week of lactation. Because less than 5% of the cows selected for this trial were excluded, and that bST-treated and control cows were excluded based on the same criteria, it is unlikely that a sizable bias was introduced from this omission.

In this study, pre-existing IMI were balanced between bST-treated and control cows.[17] This is important because cows with IMI have been observed to produce less milk than cows without infection.[18,19] Milk production in the pretrial period was well balanced between the study treatment groups. However, for one farm (farm three) milk production was marginally different between the study groups, with the control cows producing 192.3 kg more milk in the pretrial period compared to the bST-treated cows. However, for all study cows milk production during the pretrial period differed by only 46.9 kg between the study groups.

Reproductive efficiency has been cited as an important determinant of dairy farm profitability.[20] Because no differences existed between the study treatment groups for any reproductive parameter measured (ave. days to first service, ave. days open, calving interval, conception rate (first service and all services), heat detection rate, pregnancy rate and services per conception), no cost for reduced reproductive efficiency was necessary for partial budget calculations.

The difference in milk production between the study treatment groups was not calculated and displayed for each study farm. This omission was necessary because of a bias in these differences caused by unequal numbers of cows in each study group. The difference in production calculated within each farm represents an unweighted (biased) mean difference compared to the overall mean (weighted). The overall or weighted mean best estimates the difference in production between the study groups and therefore was the only difference statistically evaluated.

The overall milk production response observed in this trial was slightly less (8.5% vs. 12% production response) than observed in other studies.[1,21] It has been suggested the that actual response observed by commercial dairies may be up to 25% less than was found during experimental situations.[8] The reasons for this difference may include: 1) overcrowding of cows causing DMI to be less than maximal, 2) harsh environmental conditions (e.g., extreme heat stress resulting in reduced DMI), and 3) difference in rates of diseases that may limit milk production.

In this study, an approximately 22%, greater production response to bST in primiparous compared to multiparous cows during the study trial, period was observed. This result is in contrast to the increase in milk yield observed in other studies where multiparous cows responded to bST treatment more favorably than or more similar to primiparous cows.[1,22,23] However, another study observed that multiparous cows milked 3X responded less to bST treatment than those milked 2X with compared to similarly treated primiparous cows (production response of 5.2% for 3X compared with 11.4% for 2X milked multiparous cows (54% less response) vs. a 10.2% production response for 3X and 16.1% for 2X milked primiparous cows (37% less response).[24] These authors suggest that multiparous cows may not respond to bST treatment as well when milked 3X vs. 2X because they may have been producing near their maximum genetic potential prior to the initiation of bST treatment.[24] Also, in this study cows of differing parities responded similarly to increased milking frequency alone while other studies observed that primiparous cows responded more favorably to 3X milking than did multiparous cows.[11,25] If cows in the present study had been milked 2X and responded similarly, a 4.9 kg/day (3.6 kg/day x 37% greater response) and 4.3 kg/day (2.8 kg/day x 54% greater response) response to bST during the trial period for primiparous and multiparous cows might have been observed, respectively. It should be noted that this estimate is based upon a study where a daily bST treatment regimen was compared to the present study which utilized a 14-day sustained release preparation.[24] The increase in NFI observed in the present study agrees with an estimate made in a preapproval study.[27] However, because bST-treated cows milked 3X may respond proportionally less than those milked 2X, the change in NFI that was observed is possibly lower than would be expected if cows were milked 2X. If cows in this study had been milked 2X, the NFI per bST-treated cow would be estimated at $143.33 and $113.23 for primiparous and multiparous cows, respectively, for the trial period if cows responded to bST at comparable levels to those observed in another study.[24] This estimate closely agrees with the change in NFI attributable to bST calculated by Tauer and Knoblauch of $120.00 per cow per bST-treated lactation.[28] Therefore, while the results of the present study may accurately depict the expected increase in NFI for farms that milk cows 3X, it may underestimate the economic returns that would be expected for farms that milk cows 2X.

No returns to management or opportunity cost were included in these partial budgets. Discounting was necessary for cases of twinning because the financial loss from this “disease” was not realized until the next lactation. For financial estimates of increased NFI resulting from bST use, no discounting was considered because only a short lag time exists between the investment in bST and the payoff.[24] Actual farm and time period-specific data was used in these partial budgets because the values of inputs and outputs vary among farms and over time.[29,30] With respect to bST cost, the base price of the commercial product at the time these data were collected (1994-95) was used ($5.86/dose) was used in all financial calculations; however, many herds using bST participate in a “subscription program” which can reduce the price per dose by as much as $0.55. The cost of product reduction serves to make bST use profitable at approximately 0.14 kg less milk production response per bST-treated cow per day and increased NFI by $9.35 per bST-treated cow for the trial period.

In these partial budgets, increased DMI was assumed to occur immediately after bST treatment initiation; however, is has been observed that feed intake does not increase for several weeks following treatment initiation.[1] Justification for including increased feed cost during the early bST treatment period is that bST-treated cows have been observed to have greater energy (DMI) intakes during late lactation.[1] This serves to replenish body reserves and helps offset the lag in DMI increase observed during the early bST treatment period.

In this study, approximately 2.3 kg of production response was necessary to offset the increased costs associated with bST use. This estimate closely agrees with the results other results of a pre-approval analysis by Elbehri and Yonkers in 1995.[27] At this level of production response, a milk price of $21.86 per 100 kg is necessary to breakeven when using bST. Because the USDA has set a “floor” milk price of $21.78 per 100 kg, milk price cannot fall significantly below this calculated breakeven price for bST-assisted milk production. Therefore, if producers received the support (floor) price for milk produced while bST was being used on the farm, the production response observed during the trial period of this study would approximate the breakeven production response for milk produced with bST assistance at the USDA support price.

For this study, milk was priced at $28.09 per 100 kg, which was the average all-milk wholesale milk price for 3.5% fat milk produced during the 1994/1995 period.[28] However, these study farms likely received a higher actual ("mailbox") milk price when premiums for milk components (fat and protein) and quality (SCC and bacteria counts) were added to the Basic Formula Price. Therefore, the changes in NFI reported in this study likely underestimates actual increased revenues received by these herds from bST use. For example, if a farm received a $0.10 per 100 kg premium for milk butterfat content, NFI would be expected to increase by approximately 1.6% (from $43.01 to $42.70) from the overall estimate made for bST in this study.

A large variation in NFI attributable to bST use was observed among the four studied herds. This was primarily the result of differences in milk production response between herds as feed, bST and labor costs were found to not differ greatly between the study herds. A large variation in bST production response between herds has previously been observed.[31] Because of the large effect that production response has on the profitability of bST use, and because production response to bST varies greatly between herds, the increase in NFI associated with bST use would be expected to vary widely between herds.

For any given investment, the profitability associated with the investment depends on the relative prices of the variable inputs necessary to enact the change.[33] In this study, the price paid for bST and feed did not have a large effect on the profitability associated with bST use. Based on the current pricing scheme for bST, the difference between the highest and lowest prices paid for bST only varies by only about 9.5%. Therefore, any change in bST price would be expected to have only a small impact on the product's profitability. Similarily, because cows only experience a small increase in DMI in response to bST treatment (DMI has been observed to increase approximately 4 to 6%),[1] changes in feed price have little impact on bST-associated profitability. Nevertheless, it has been stated that bST use will be least profitable when milk prices are low and feed prices are high.[32] Overall, the profitability of bST use depends primarily on the level of milk production response and ultimately on milk yield per cow.[27] Because of it's major impact on bST (and overall farm) profitability, the importance of frequent monitoring of milk yield per cow cannot be overemphasized.

As this study only considered a single lactation, it is possible that additional costs or revenues could be realized in subsequent lactations that could impact the economics of bST use, and these factors were not included in this analysis.[33] However, culling during the study lactation and milk production during the first 63 days of the next lactation were analyzed in the present study and were found to be similar between bST-treated and control cows. Therefore, while it is unlikely that any significant costs or revenues would be carried over into subsequent lactations, the costs of the inputs required for bST use (bST product, labor and additional feed) as well as the price of outputs (milk) may change over time and significantly affect the economics of bST use. It has been observed that the most common price fluctuation affecting dairy farms is feed price changing relative to the price of milk.[34] Based on the results of this study, bST-assisted milk production would be most profitable when the price received for milk is high, but an increase in the price paid for feed would not dramatically reduce bST-associated profitability.

In this study, cows experiencing a non-specific off feed condition had no lost income because little therapy was necessary and no significant decrease in milk production occurred. However, a case of twins was calculated to cost $84.39 after discounting this cost by 10%; this discounting was necessary because the loss (due to twinning) was not incurred until the subsequent lactation. This cost was similar to that found by other workers and found that c cows bearing twins produce more total calf value, but this was offset by increased calf mortality, greater rates of diseases (retained placenta and metritis), more days spent open and higher culling rates compared to non-twinning herdmates.[35,36]

In this study, bST-treated cows were more than twice as likely to conceive twins than were control cows (relative risk = 2.13). When this increased risk is applied to the incidence of twins observed prior to bST use in the herds studied (6.0% lactational incidence) and the cost of a case of twins in these data, NFI resulting from bST use was decreased by $0.78 (1.8% of the expected benefits of bST) per bST-treated cow per lactation.

In the four herds that were studied, bST was not associated with an increase in clinical mastitis, and although lameness was not monitored during this trial, the (indirect) effects of lameness were evaluated via the comparison of culling and milk production between bST-treated and control cows. However, a meta-analysis that was conducted in Canada, which combined the weighted effects of many bST studies, concluded that bST increased the risk of clinical mastitis by 25% and lameness by 50%.[37] Clearly, herds in which bST may be associated with economic losses because of these diseases will need to consider such losses as additional expenses when estimating the change in NFI from bST use in their herds.

Table 1: Pretreatment (from Day 4 to 63 of lactation) milk production estimates for actual milk produced for cows supplemented with 500 mg of bST (Posilac^{R}, Monsanto Co., St. Louis, MO) at 14-day intervals beginning at approximately 63 days of lactation until the end of lactation compared to untreated control cows (kg/first 63 days of lactation).

	bST , (n)	Control, (n)	Total n	*P*-value
Farm 1	2471.2 (41)	2572.7 (27)	68	0.36
Farm 2	1766.5 (111)	1745.0 (113)	224	0.77
Farm 3	2170.0 (69)	2362.2 (66)	128	0.03
Farm 4	2073.1 (63)	2177.1 (65)	135	0.23
Lactation = 1	1721.8 (107)	1675.7 (86)	193	0.45
Lactation > 1	2223.1 (177)	2270.0 (185)	362	0.43
Total	2034.3 (284)	2081.4 (271)	555	0.34

Table 2: Peak milk production and time to peak milk production for cows supplemented with 500 mg of bST ((Posilac^{R}, Monsanto Co., St. Louis, MO) at 14-day intervals beginning at approximately 63 days of lactation until the end of lactation compared to untreated control cows.

Milk Production		BST	Control	Difference	Total	*P* – value
Peak milk production (kg/day)						
	Lactation = 1	46.4	42.3	4.1	44.6	0.0001
	Lactation > 1	53.4	51.9	1.5	52.6	0.0925
	Total	50.8	48.9	1.9	49.8	0.0119
Time to peak production (days)						
	Lactation = 1	138.0	108.8	29.2	125.0	0.0010
	Lactation > 1	99.4	76.0	23.4	87.4	0.0001
	Total	113.9	86.4	27.5	100.5	0.0001

Table 3: Correlation (Pearson's) of the first three (after bST treatment initiation) and final (305-day) DHIA milk production estimates with actual milk produced (daily milk weight measurements) for cows supplemented with 500 mg of bST ((Posilac[R], Monsanto Co., St. Louis, MO) at 14-day intervals beginning at approximately 63 days of lactation until the end of lactation compared to untreated control cows.

Milk production measure	BST (r_{bST})	Control (r_{bST})	*P* - value[a]
First DHIA estimate	0.7242	0.7334	0.41
Second DHIA estimate	0.8329	0.8323	1.00
Third DHIA estimate	0.8501	0.8382	0.35
Final DHIA estimate	0.9753	0.9824	1.00

[a] *P*-value reflects difference between correlations in the same row.

Table 4: Differences in milk production between the first three (after bST treatment initiation) and final (305-day) DHIA milk production estimates and actual milk produced (measured by daily milk weight measurements) for cows supplemented with 500 mg of bST ((Posilac[R], Monsanto Co., St. Louis, MO) at 14-day intervals beginning at approximately 63 days of lactation until the end of lactation compared to untreated control cows.

Milk production measure	bST (kg/lactation)	Control (kg/lactation)	Difference (bST – control)[a]	*P* - value[b]
Actual milk production	10195.9	9645.0	550.9	0.004
First DHIA estimate	9721.8	9572.3	149.5	0.417
Difference (actual – first)	509.6	73.1	436.5	0.001
Second DHIA estimate	9916.4	9657.3	259.1	0.148
Difference (actual – second)	315.3	(12.3)	327.6	0.002
Third DHIA estimate	10128.6	9681.4	447.2	0.019
Difference (actual – third)	102.9	(36.3)	139.2	0.188
Final DHIA estimate	10436.4	9869.6	566.8	0.003
Difference (actual – final)	(240.4)	(224.5)	15.9	0.679

[a] Absolute difference in milk production between bST-treated and control cows.

[b] *P*-value reflects absolute difference in milk production between bST-treated and control cows.

Table 5: Partial budget analysis for cows supplemented with 500 mg of bST ((Posilac[R], Monsanto Co., St. Louis, MO) at 14-day intervals beginning at approximately 63 days of lactation until approximately 301 days of compared to untreated control cows (dollars/supplemented period/cow).

	Farm 1	Farm 2	Farm 3	Farm 4	Average
A. INCREASED INCOME					
1. Supplemented days per lact.	238 days	238 days	238 days	238 days	238 days
2. Ave. daily increased milk prod.	3.9 kg	2.1 kg	3.6 kg	1.9 kg	2.9 kg
3. Total additional prod. from bST	928.2 kg	499.8 kg	856.8 kg	452.2 kg	571.2 kg
4. Gross milk price per 100 kg	$28.09	$28.09	$28.09	$28.09	$28.09
5. Total added revenue from bST	$260.73	$140.39	$240.68	$127.02	$192.21
B. REDUCED COSTS					
None identified in this analysis	$0.00	$0.00	$0.00	$0.00	$0.00
C. SUBTOTAL (section A + B)	$260.73	$140.39	$240.68	$127.02	$192.21
D. REDUCED INCOME					
None identified in this analysis	$0.00	$0.00	$0.00	$0.00	$0.00
E. INCREASED COSTS					
6. Number of bST doses per lact.	17	17	17	17	17
7. Cost per dose of bST	$5.86	$5.86	$5.86	$5.86	$5.86
8. Total bST product cost per lact.	$99.62	$99.62	$99.62	$99.62	$99.62
9. Tim required per injection/dose	1 min.	1 min.	1 min.	1 min.	1 min.
10. Labor cost per hour	$10.00	$10.00	$10.00	$10.00	$10.00
11. Total labor cost per lact.	$2.83	$2.83	$2.83	$2.83	$2.83
12. Additional Mcal required/kg milk[a]	641 Mcal	345 Mcal	592 Mcal	312 Mcal	473 Mcal
13. Feed cost per Mcal/ kg addit. milk	$0.087	$0.082	$0.083	$0.084	$0.084
14. Total additional feed cost per lact.	$55.80	$28.32	$49.14	$26.25	$39.88
15. Other added costs per lactation[b]	$11.23	$6.05	$10.37	$5.47	$8.28
16. Total additional costs per lactation	$169.49	$136.82	$161.96	$134.17	$150.61
F. SUBTOTAL (section D + E)	$169.49	$136.82	$161.96	$134.17	$150.61
NET GAIN (line F – line C)	$91.25	$3.57	$78.71	$(7.15)	$41.60

[a] 0.691 Mcal/Kg of milk[b] Milk marketing cost = $1.21 per 100 Kg

Table 6: Partial budget analysis for cows supplemented with 500 mg of bST ((Posilac[R], Monsanto Co., St. Louis, MO) at 14-day intervals beginning at approximately 63 days of lactation until approximately 301 days of compared to untreated control cows (dollars/supplemented period/cow).

	Lact. = 1	Lact. > 1	Average
A. INCREASED INCOME			
1. Supplemented days per lact.	238 days	238 days	238 days
2. Ave. daily increased milk prod.	3.6 kg	2.8 kg	2.9 kg
3. Total additional prod. from bST	880.6 kg	642.6 kg	690.3 kg
4. Gross milk price per 100 kg	$28.09	$28.09	$28.09
5. Total added revenue from bST	$247.36	$180.51	$193.88
B. REDUCED COSTS			
None identified in this analysis	$0.00	$0.00	$0.00
C. SUBTOTAL (section A + B)	$247.36	$180.51	$193.88
D. REDUCED INCOME			
None identified in this analysis	$0.00	$0.00	$0.00
E. INCREASED COSTS			
6. Number of bST doses per lact.	17	17	17
7. Cost per dose of bST	$5.86	$5.86	$5.86
8. Total bST product cost per lact.	$99.62	$99.62	$99.62
9. Tim required per injection/dose	1 min.	1 min.	1 min.
10. Labor cost per hour	$10.00	$10.00	$10.00
11. Total labor cost per lact.	$2.83	$2.83	$2.83
12. Additional Mcal required/kg milk[a]	608 Mcal	444 Mcal	477 Mcal
13. Feed cost per Mcal/ kg addit. milk	$0.08	$0.08	$0.08
14. Total additional feed cost per lact.	$51.11	$37.30	$40.06
15. Other added costs per lactation[b]	$10.66	$7.78	$8.53
16. Total additional costs per lactation	$164.22	$147.53	$150.87
F. SUBTOTAL (section D + E)	$164.22	$147.53	$150.87
NET GAIN (line F – line C)	$78.12	$37.99	$43.01

[a] 0.691 Mcal/Kg of milk

[b] Milk marketing cost = $1.21 per 100 Kg

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Endnotes:

[a] Posilac^{R}, Monsanto Co., St. Louis, MO

[b] DairyComp 305^{R}, Valley Agricultural Software, Tulare, CA

[c] The SAS System for Windows^{R}, Version 6.10, SAS Institute, Cary, NC

[d] Excel^{R}, Version 5.0, Microsoft Corp., Redmond, WA

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