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ECONOMICS OF RECOMBINANT BOVINE SOMATOTROPIN ON U.S. DAIRY FARMS

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Since its adoption in 1994 in the United States (U.S.), Monsanto's rBST product, Posilac®, has been very rapidly adopted by the commercial dairy industry. It has been shown in repeated studies to be safe for cows and to be both effective and profitable if used in adequately managed dairies. It has been widely affirmed as safe for consumers of dairy products. The economic value of rBST is exerted by increasing the production of existing cows. The prinicpal cash costs for using this technology are the cost of the product and the additional feed needed to produce the milk, with some additional labor or capital costs on some dairies. Under typical conditions, the use of Posilac® in adequately managed dairy herds returns well over 50% profit over the expenses at typical prices for milk and feed. By increasing production in existing cows, the technology spreads fixed costs over more production, increasing the margin and profits for the farm. The use of rBST is generally scale neutral and has a positive environmental impact by reducing the amount of manure produced per gallon of milk.

Key words: Posilac®; BST; dairy; economics; biotechnology.

Posilac®, Monsanto's genetically engineered version of bovine somatotropin (rBST), was approved for use in lactating dairy cows in the U.S. in February, 1994. In addition, 25 other countries have given approval for its use in dairy cows. Before and since its approval, the product has been intensely scrutinized and studied. It is now widely used on commercial dairies across the United States.

Basic Biology Of rBST As Used In Commercial Dairies

Monsanto's rBST product, Posilac®, is labeled for use by subcutaneous injection every 14 days in milking cows. The dairyman can begin its use in the 9th week after the cow calves and begins her lactation. Its use is typically maintained for the remaining 8 – 10 months of the cow's lactation cycle. This allows the cow to begin her lactation, recover from the effects of pregnancy and calving, and begin to consume adequate feed to support full production. Posilac® rBST is a protein hormone, altered from one variant of the cow's naturally occurring somatotropin by the addition of one amino acid at the end of the molecule. The recombinant protein has the same biological activity as the naturally occurring one. The hormone is only effective if injected. If eaten, rBST is simply digested the same as any other protein. High producing cows have been shown to naturally have higher levels

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of BST than low producing cows. In simple terms, the hormone will increase the milk production of healthy cows that are provided additional feed to support increased production. Typically, cows produce from 5 to 15 more pounds of milk per day (a typical cow produces about 60 pounds of milk per day). Cows respond by eating more feed and producing more milk.

Effects Of rBST On Production And The Health Of Cows

Bovine somatotropin has its effect at the margin of production; the cow is already making milk and simply makes more milk. In nutritional terms, the cow must consume additional feed (nutrients) to support the increased margin of production, but her needs for maintenance have already been met. Thus, additional feed inputs can be committed entirely to milk production. If the cow is not fed to support additional production, she will not make more milk. The hormone cannot "force" production, nor does it "burn out" cows. The composition of the milk from rBST treated cows is not altered (butterfat, protein, lactose) and, thus, has the same manufacturing characteristics of all milk (cheese, butter, yogurt, ice cream, and so on). The level of BST in milk from treated cows is the same as for untreated cows.

The production response to rBST depends on the quality of management provided on the dairy. For maximum response, cows must be fed adequate additional quantities of a properly balanced diet. In addition, factors such as cow comfort, hygiene, proper ventilation, heat abatement in hot and humid weather, water, and general health also contribute to the ability of the cow to respond to the product. These are the same factors that influence optimal production in any dairy cow. In general, cows given rBST suffer few additional health problems compared to untreated cows. Initial studies that led to product approval showed slight increases in the time it took cows to become pregnant and slight increases in mastitis (udder infections) for treated cows. Both detected increases were small compared to the wide variability of these attributes within and between dairy farms. Other minor health effects were variably seen in some pre-approval studies.

As part of the product's approval, and in the face of strident political controversy at its release, the Food and Drug Administration (FDA) required a significant post-approval study by Monsanto regarding the product's use and safety. Particularly as a result of the slight increase in mastitis in treated cows, there were concerns that the use might induce farmers to treat more cows with antibiotics and, thus, increase the rate of contamination of milk destined for human consumption. The post approval study found no such effect. The slight increase in the rate of mastitis was again confirmed in those studies, at least in older cows, but the rate was less than previously reported. Reproductively, the product did slightly decrease the efficiency with which cows become pregnant, prolonging the time to conception slightly. Interestingly, the increased production associated with the product has caused some farmers to voluntarily delay re-breeding their cows. This increases the time until the cow becomes pregnant again, prolongs the lactation, and reduces the number of calvings per year on the farm. The period around calving is the highest risk period for disease in the cow and this management strategy may actually reduce the incidence of disease.

A recent very large study in New York tracked 340 commercial dairy herds, one half that never used rBST and one half that used the product at a significant level (more than 50% of cows) since the product was introduced. The study involved over 80,000 cows over more than 200,000 lactations. Production and other aspects were compared to the four-year baseline set in all herds pre-rBST. The results confirmed the production responses found in earlier studies. The production response was consistent through all four years examined. There was no difference in reproductive performance for herds using the product compared to control herds. There were no differences in average age of cows in the two groups, indicating that treated cows are no more likely to be culled or die early than untreated cows. As was true in previous studies, there were slight increases in somatic cells in milk

from treated herds (an indicator of some increased mastitis). In summary, the product has been shown to be effective in healthy, properly fed cows and to be safe for cows in wide adoption across the spectrum of U.S. dairy herds.

Degree Of Adoption Of Monsanto's Posilac®

Since its approval in the U.S. in 1994, Posilac has been very rapidly adopted by the dairy industry. Sales increased by 45% from 1995 to 1996, by 30% from 1996 to 1997, and 30% from 1997 to 1998. Of the nearly 9 million dairy cows in the U.S. approximately 30% receive the product during a lactation. The product is used in herds in all states, with approximately 13,000 dairy farms having used the product. Farms of all sizes use the product, from the small farms of the upper Midwest (typically about 50 cows) to the large farms more typical of the West (1,000 cows and up). More than half of all herds that use the product have fewer than 100 cows. The average producer uses rBST on more than half of the herd at any given time (some cows are not milking, some are too early in lactation for its use, and the farmer elects not to treat some).

Economics

At the farm level, the economics of Posilac® are fairly simple. The farmer must pay for the product ($5.25 per dose if the product is used on at least 60 percent of the herd's cows). The cow must eat more feed to support her increased milk production. The revenue comes from the sale of the extra milk, typically 8 to 12 pounds per cow per day at a price of 11 to 15 cents per pound. This cycle is repeated every 14 days as the cow is re-injected. For some farms, there are additional costs for extra labor to sort and inject the cows. In general, there are few, if any, capital costs involved in the use. On some farms, alterations to the cow handling or feeding systems are needed to adopt rBST use, but generally these costs are small compared to the profit and breakeven payback is quickly achieved.

Tables 1 and 2 illustrate a typical scenario for the economics of rBST use on a hypothetical 100 cow dairy farm using the product. Table 1 details the assumptions underlying the economic model of rBST use on the hypothetical farm. Ninety percent of the cows will be treated according to approved label instructions during their lactation, that is, 10% will not be treated at all during the lactation period.

Table 2 details the profitability of the dairy operation based on various production responses by the herd. The economic impact at a typical 10-pound production response is $10,856 profit for the 100 cow dairy or approximately $110 per cow for all cows or about $120 per treated cow. The average upper Midwest dairy only earns approximately $400 profit per cow per year in a typical year. Given the assumptions in the scenario, the added profit from the use of Posilac® provides a very significant increase of 23% in overall farm profitability.

The profitability of rBST depends greatly on the price of milk. The contribution to overall farm profitability depends on the cost structure of the farm as well. In general, as the price of milk drops the profit from the use of rBST drops as well. Paradoxically, the percent contribution of rBST to overall farm profit may increase as the price of milk drops, since the overall farm profit may drop faster than the proportional contribution of the added milk from rBST use.

The economic risk of rBST use to the farmer is that cows will not respond by increasing production enough to cover the added expenses. This particular technology has the advantage that the response is quick, measurable, and easily valued in dollars. Production increases are typically apparent after the second or third dose and then are sustained. For farms whose cows do not respond, the controlling bottleneck to production can be identified and removed, permitting treated cows to

respond. In most cases, the problem was reducing production in any case and the investigation and intervention improve the dairy's management. Since few significant capital investments are typically needed to test the value of the investment in rBST, farms can adopt the product on a trial basis with little financial risk.

Limits To The Effective Application Of The Technology

Not every farm that uses Posilac® sees a positive production response. The physiology of their cows is the same as other farms; it is the farm's management of cows that creates the bottleneck for response. In practical use, there are several factors that require attention if the dairy wants an optimal production and economic response from Posilac®. Most of the management issues are the same as for any effort to improve milk production. Responses are highest on well managed dairies. The most critical need is nutritional. Cows must be fed adequate amounts of a well balanced diet in order to respond in production. For some herds this may require additional attention to feed procurement, nutritional consultation, feeding facilities and feed management. Proper housing to assure good cow comfort, good ventilation, and adequate hygiene improve cow health and feed intake. To use the product appropriately, the dairy must have an adequate cow identification and record system to be able to assure that the proper cows are injected. These are generally standard features of most dairy farms, but for the most poorly managed farms these would be new features for management. Sorting the cows to be injected and restraining them for injection requires a marginal increment in labor and for some farms requires new facilities for handling the cows. While in general the use of rBST is scale neutral, these latter aspects tend to be more significant issues on larger farms.

Human Health Concerns

Because all mammals produce somatotropins and because of the importance of somatotropins in growth and other physiologic processes, there was a significant concern about the potential impact that rBST might have on human health. Somatotropins are fairly species specific and human and bovine somatotropins are quite different. In fact, about 35% of the amino acids in human somatotropin differ from those of bovine somatotropin. Even when injected in large doses, rBST has no effect in humans.

Milk and milk products (cheese, yogurt, and so on) have always contained BST; it is a natural component of milk. Milk from rBST treated cows has no higher levels of the hormone than milk from untreated cows. When eaten, rBST is digested like any protein. Its human safety has been confirmed by governmental, academic, and professional organizations around the world, including the FDA, World Health Organization, American Medical Association, and the UN Food and Agriculture Organization (FAO). Even the European Commission and the Canadian regulatory agencies involved in considering the use of the product concur that it is safe for humans, even though both bodies have postponed approval in their countries for political reasons.

In an effort to capture the potential market for milk from consumers who remain concerned about health issues, some dairy processors market fluid milk specifically labeled as coming from cows not treated with rBST. This market is very small; probably no more than one or two percent of the fluid milk market. There is very little "not treated with rBST" market for manufactured dairy products (cheeses, butter, and so on). Fears that the consumer would suddenly avoid dairy products when rBST was introduced were unfounded. Liquid milk consumption increased about 1% in the U.S. in the ten months of 1994 that followed the introduction of the product and has continued to rise.

Environmental Concerns

Nearly 100 million doses of Posilac® have been used since its introduction into commercial dairies. With that volume of use comes the need to deal with 100 million syringes. Monsanto has responded to that concern by arranging for free mail disposal services for used syringes. The dairy producer simply discards syringes in a container delivered with the product and mails them back for proper disposal as medical waste.

The public is increasingly concerned about the impact of animal manure on the environment, particularly surface and groundwater. A typical dairy cow supplemented with rBST produces more milk, eats more feed, and therefore produces more manure. Per pound (or gallon) of milk produced, however, the rBST treated cow makes less manure. This is because the extra milk requires only a marginal increment in feed to produce milk, not more feed to maintain the cow herself. If the same milk is produced by the dairy industry with fewer cows (higher production per cow), then there are fewer cows eating feed for maintenance and, thus, less manure produced. This effect of improved production is true for any production enhancing technology. These effects can be dramatic over time. For example, in Minnesota it has been estimated that overall improved production per cow since 1950 has led to a nearly 40% decrease in manure production per gallon of milk produced. The widespread adoption of rBST will add to this effect. Improved production per cow also reduces the feed needed to support a given level of production in the industry, reducing the need for crop land devoted to the dairy industry, water use in crop production, and the use of fuel and agricultural chemicals.

Summary

Since its adoption in 1994 in the U.S., Monsanto's rBST product, Posilac®, has been very rapidly adopted by the commercial dairy industry. It has been shown in repeated studies to be safe for cows and to be both effective and profitable if used in adequately managed dairies. Its economic value is exerted by increasing the production of existing cows and, thus, is generally independent of the scale of the farm. The principal cash costs for using this technology are the cost of the product and the additional feed needed to produce the milk. Small increments in labor costs may play a role, as well as other management changes needed to take full advantage of the product. Under typical conditions, the use of Posilac® in adequately managed dairy herds returns well over 50% profit over the expenses at typical prices for milk and feed. There are usually few, if any, capital costs involved in its adoption. For these reasons, the product has gained rapid adoption and appears to be becoming a standard part of typical commercial milk production.

The social impacts will likely to be similar to those for any agricultural production enhancing technology: fewer production units (cows and farms) and lower consumer prices for food. Because the aggregate effect will be to reduce the number of cows being maintained for production, the product will reduce the demand for feed, and therefore agricultural crop production committed to the dairy industry with attending reductions in the use of water, fuel, and crop inputs. Production of manure per gallon of milk will also be reduced, reducing the environmental impacts at a given level of national milk production. Viewed broadly, the development of rBST for dairy cows has been a remarkable example of the impact and value of biotechnology on food production.

Table 1. Economic Model For The Use Of rBST.

Assumptions	
$12.50 milk price / 100 pounds	120 days from calving to conception
100 cows in the herd	70 days from the end of lactation to the next calving
90% of cows treated with rBST	63 days to start of rBST treatment
0.33 Mcal energy per pound of milk	400 interval from one calf to the next
0.78 energy density of ration per pound of DMI	267 days of rBST use / lactation (assumes continuous use to the end of lactation)
$0.080 price of ration per pound of dry matter	60% of herd will be treated on average at any given time
$5.25 price per dose for Posilac	$0.00 other rBST related costs / cow / year
4.0 hours spent each two weeks for labor	$10.50 non-rBST related costs / 100 lbs milk
$8.00 wage rate per hour	18,000 lbs production /cow without rBST
$834 cost for labor per year	

Table 2. Profitability Of rBST Based On Economic Model.

Prod-uction response (lbs)	Costs Per rBST Treated Cow Per Year				Profitability (per year)			Impact On Total Farm Profit			
	rBST Costs	Extra Feed Costs	Non-Feed Cost	Total rBST Related Costs	Value Of Milk Per Treated Cow	Profit In The Herd	% Profit Over All rBST Related Expenses	Costs Related To rBST	Milk Income From rBST	General Farm Profit Per Year	% Of Farm's Profit From rBST
4	$91	$33	$9	$134	$122	($1,092)	-9%	$12,056	$10,964	$34,908	-3%
5	$91	$42	$9	$142	$152	$889	7%	$12,805	$13,705	$36,899	2%
6	$91	$50	$9	$151	$183	$2,891	21%	$13,555	$16,446	$38,891	7%
7	$91	$58	$9	$159	$213	$4,882	34%	$14,305	$19,186	$40,882	12%
8	$91	$67	$9	$167	$244	$6,873	46%	$15,054	$21,927	$42,873	16%
9	$91	$75	$9	$176	$274	$8,864	56%	$15,804	$24,668	$44,864	20%
10	$91	$83	$9	$184	$305	$10,856	66%	$16,554	$27,409	$46,856	23%
11	$91	$92	$9	$192	$335	$12,847	74%	$17,303	$30,150	$48,847	26%
12	$91	$100	$9	$201	$365	$14,838	82%	$18,053	$32,891	$50,838	29%
13	$91	$108	$9	$209	$396	$16,829	90%	$18,803	$35,632	$52,829	32%
14	$91	$117	$9	$217	$426	$18,820	96%	$19,552	$38,373	$54,821	34%
15	$91	$125	$9	$226	$457	$20,812	103%	$20,302	$41,114	$56,812	37%
16	$91	$133	$9	$234	$487	$22,803	108%	$21,052	$43,855	$58,803	39%
17	$91	$142	$9	$242	$518	$24,794	114%	$21,801	$46,596	$60,795	41%

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