General Session III

New Technologies and Bovine Medicine

Dr. George E. Washington, *Presiding*

Bovine Somatotropin—What Veterinarians and Their Clients Need to Know in 1986

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Since the '50s we've been living in an age of rapid technological change. Development started slowly, but the pace has quickened to the point that we now learn almost weekly of new breakthroughs in electronics and biology. Advances are rapid — everything from probes deep into outer space to the use of robots in manufacturing processes and to the use of insulin and growth hormone produced by bacteria for treating human disease.

Predictions are that the speed at which we'll implement new electronic and biotechnological advances will increase in the next 15-20 years. Agriculture in general and animal production in particular will be at center stage in this continuing technological revolution.

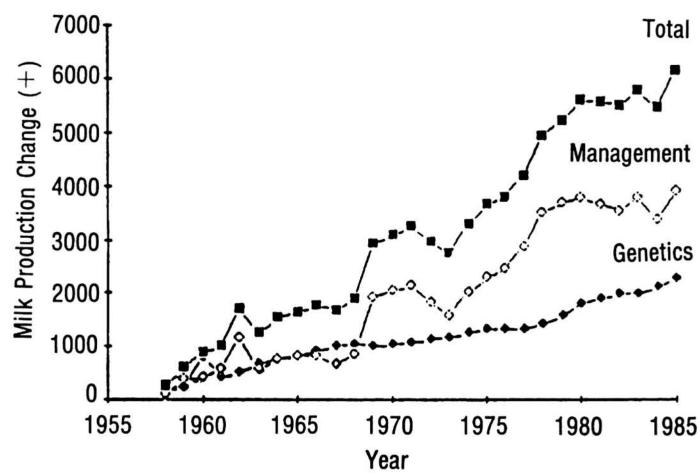
Time and space do not permit an adequate discussion of how new technologies will affect various animal production systems. In this paper we'll discuss one new technology, the new use of bovine growth hormone to increase the efficiency of milk production. It will serve as an example (albeit in all probability a more dramatic one than many) of the potential of new technology to affect animal production. Emphasis throughout will be on information that dairy farmers (and their advisors) need in order to make informed decisions about their businesses both today in anticipation of growth hormone and in the future when (if?) it becomes commercially available.

New Technology in Perspective

Agriculture industry research and land-grant college research, extension and teaching have always emphasized the development and implementation of new technologies and improved management practices to increase the efficiency of agricultural production. Since 1930, technologies (some of which can rightfully be termed "biotechnology") have been developed and implemented in dairy production systems. These include: nutrient requirements/ration balancing; DHI production records; artificial insemination/generic selection; milking machines; free stall housing/milking parlors; disease control, and the protein solubility concept.

Implementation of these technologies has dramatically increased the efficiency of dairy production. Production per cow has increased 6,000# in NY Holsteins since 1958 (Figure 1). Improved genetics (A.I., sire selection, and sire evaluation) provided 2,000# of the increase; improved management practices and the implementation of other new technologies accounted for the remaining 4,000#.

FIGURE 1. Milk Production In NY Holsteins.



R. W. Everett, 1985.

The result has been the ability to produce more milk (and more profit) at a fixed animal maintenance cost — improved efficiency of production. Dairy farmers have enjoyed the benefits in terms of increased profit, improved quality of life and the ability to market a product that competes favorably on a price basis for the shoppers' dollar. Consumers have benefited from the availability of an abundant, relatively low cost supply of high quality dairy products.

The new technology and the resulting increased production per cow have also challenged the dairy farmer. New technology has required a higher level of management. In addition, the consumption of milk and the utilization of dairy products has not kept pace with production increases. As a result of this and efficiencies of scale, commercial dairy farm numbers in NY have declined by about 78% and cow numbers by 30% since 1950 (Table 1) while farms and herds have become larger. Farmers who have left dairying have adjusted well, but not without some difficult times. They have established satisfying alternative careers.

TABLE 1. Number Commercial Dairy Farms, Number of Cows and Production Per Cow In New York.

Year	No. Farms[1]	No. Cows (million)	Milk/Cow (pounds)
1950	60,000	1.30	6,800
1955	55,000 (8%)	1.37	7,200
1960	40,200 (27%)	1.25	8,200
1965	30,500 (24%)	1.17	9,500
1970	22,000 (28%)	0.95	10,900
1975	17,000 (23%)	0.92	10,900
1980	14,400 (15%)	0.91	12,000
1985	13,400 (7%)	0.94	12,700

G. J. Conneman, Dept. Agr. Econ., Cornell University.
[1]Numbers in parenthesis are % change during previous 5 year period.

The development and implementation of new technology will continue. There will be improved methods of disease prevention, diagnosis and treatment. Technologies that will improve nutrition (computerized feeders), reduce milk hauling costs (ultrafiltration) and improve herd management decisions (computerized record analysis and decision aids) are in various stages of development. Sire evaluation and sire selection will continue to improve. Additional nutritional supplements like Monensin and "Isoacids" will become available. All of these plus bovine growth hormone (if and when it becomes commercially available) are predicted to result in continued increases in the efficiency of milk production.

What is Somatotropin?

Somatotropin is the scientific name for growth hormone. It is a naturally occurring protein hormone that is comprised of 191 building blocks called amino acids. These amino acids are the same as those that make up other plant and animal proteins. Because it is a protein, somatotropin cannot be fed to cows. The digestive enzymes would inactivate it by splitting it into its amino acid building blocks just as they digest other proteins. For this reason, somatotropin must be injected.

Somatotropin is produced daily by the pituitary gland at the base of the brain in man and all farm animals. Researchers began to learn the functions of somatotropin as early as the 1930's, and 40's when it was discovered that it is important in controlling the normal growth processes of animals. Soon after, it was learned that somatotropin is required for normal lactation and that it stimulates milk production in ruminants. In fact, somatotropin injection to increase milk production was seen as a possible method for relieving the food shortage in Great Britain during WW II (9). The problem was that the only source of somatotropin was the pituitary glands of cattle that had been slaughtered for beef. Since it required the pituitaries of 200 cows to obtain enough somatotropin to treat 1 cow for 1 day, this was obviously not a practical approach for the 1940's.

In the 1980's, new biological techniques called "genetic engineering" were developed. These technologies allow isolation of the genes which are responsible for programming an animal cell to produce a specific biological product and the insertion of these genes into bacteria. The bacteria will then produce the substance that is normally only produced by the animal. Thus, large quantities of the animal product can be manufactured by bacteria in fermentation vats and purified very inexpensively. Bacteria produce most of the human insulin that is used to treat diabetics and human growth hormone produced by this method has also recently been approved for the treatment of dwarfism in humans. This and other biotechnology is now used to make products for disease diagnosis, prevention, and treatment.

By the same technology, *E. Coli* bacteria can now be used to produce bovine somatotropin for research and potential commercial application in dairy cattle (5). Much of the bovine somatotropin produced to date has been used for university research. The experiments have been designed to study factors that control milk production and to determine why some cows produce more than others.

Several large corporations also have a great interest in bovine somatotropin because of its potential for commercial application. Many are conducting their own research as well as supporting work at universities. Increased agricultural efficiency and profit for both dairy farmers and their stockholders are among the motives for the activities of these companies.

Somatotropin Research Results

Many of the recent studies on the effect of the administration of somatotropin to dairy cows have been conducted by Dr. Dale Bauman at Cornell. Emphasis here will be on the latest "long term" Cornell study using the bacteria-produced product (2). High producing cows were selected for the study and housed at Cornell's Animal Science Teaching and Research Center. They received somatotropin injections daily for 188 days beginning at about 84 days after calving (about the last 2/3 of lactation). Note that the cows did not receive somatotropin for a full lactation.

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It's also important to keep in mind that the research was conducted under excellent nutritional management. The results might, therefore, be considered maximal. A lower response would probably have been observed under "average" farm conditions and one might project that there would be no response in a "poorly managed" herd.

The rations were formulated and fed according to production level approximately as they would be in a commercial herd with three production groups (high, medium, low). They were typical of those fed on many Northeast farms. (Table 2)

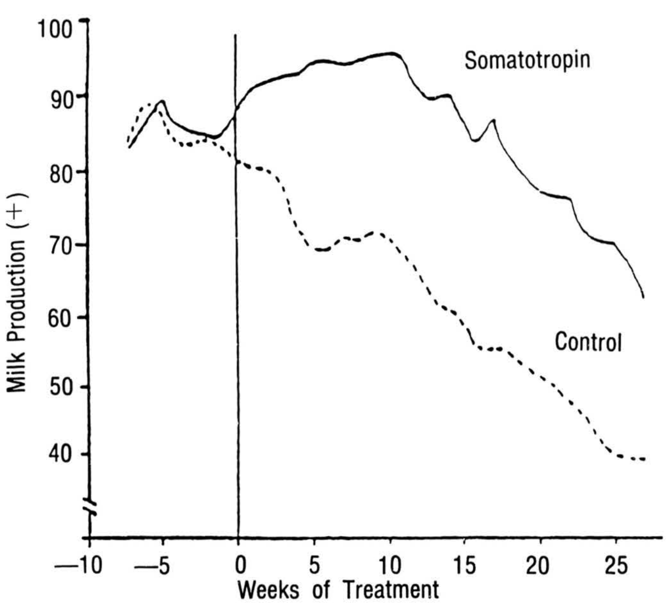
TABLE 2. Cornell Research — Rations.

	Energy Level[1]		
	High (80# milk/day)	Medium (60# milk/day)	Low (45# milk/day)
Hay Crop Silage (%)	20.0	29.3	38.3
Corn Silage (%)	19.6	25.2	37.5
Shelled Corn (%)	41.8	30.2	14.0
SBM (%)	15.3	12.3	8.5

[1]High = 0.74 Mcal NEL/lb; Med. = 0.71 NEL/lb; Low=0.69 NEL/lb.

The milk production of the somatotropin-treated and control cows is shown in Figure 2. All cows had peaked in production (90# per day) before the start of the experiment (week "0", 84 days into lactation). Cows receiving somatotropin peaked again at a higher level (about 97# per day) after treatment started. Milk composition (fat, protein, lactose and minerals) was not affected by somatotropin treatment. Treated cows maintained the production increase compared to controls as long as somatotropin was administered. Control cows continued on a normal lactation curve.

FIGURE 2. Cornell Results — Milk Production.



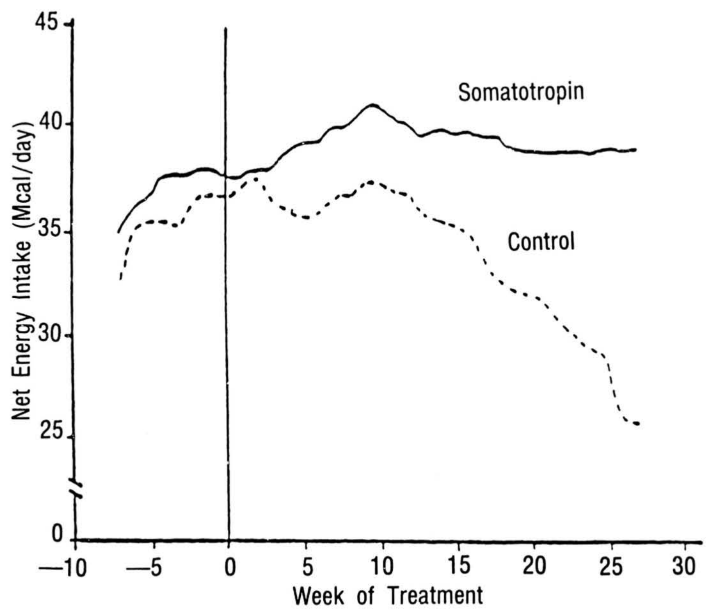
Bauman, Eppard, DeGeeter and Lanza, 1985.

Daily milk production was increased by 41% (87# vs 61#) while somatotropin was being administered. This is the important figure to keep in mind when considering the feeding program for these cows. However, for many purposes we're really interested in the increase that can be expected on a whole lactation basis. The numbers are quite different. Keeping in mind that this was not a full lactation study, treated cows on this experiment produced about 25% more milk than the untreated control cows over the entire lactation; controls produced 21,000# in 305d.

Recently three longer-term studies were reported (1, 3, 8). The experiments were conducted at the University of Pennsylvania, Minnesota and Kentucky with 32 cows being utilized at each location. Varying daily doses (0, 12.5, and 50 mg) of recombinant-derived somatotropin were administered by daily subcutaneous injection beginning at 4-5 weeks post-calving and continuing for 37-38 weeks. These longer studies confirm the dramatic effect of somatotropin on milk production that was observed in the shorter Cornell study. While somatotropin injections continued, daily milk production in treated cows averaged 17%, 22% and 24% more than in controls in the three studies. Maximal responses ranged from 21%-34%. As with the Cornell data, remember that these were not whole lactation studies so the increase in production over the entire lactation would be somewhat less.

The energy intake of the somatotropin-treated cows in the Cornell Study is shown in Figure 3. Energy intakes increased and were maintained at a higher level in the cows that received somatotropin. The energy density of the ration remained constant, so the increased intake was simply due to the fact that the cow ate more of the ration that was balanced for 80# of milk production per day. Their dry matter intakes

FIGURE 3. Cornell Results — Energy Intake.



Bauman, Eppard, DeGeeter and Lanza, 1985.

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increased. Because of the increased production, the cows stayed on the "high group" ration longer than the control cows did. The extra milk produced when somatotropin is administered requires that cows consume more feed.

Like all high producing cows, the control cows in the Cornell Study (and the treated cows prior to somatotropin administration) consumed large amounts of feed (Table 3). The treated cows consumed even more (an extra 8# of dry matter per day when they were receiving somatotropin) to support the production increase. Similar results were observed in the Pennsylvania, Minnesota and Kentucky studies (11% increase in the Minnesota study). To derive the benefits of somatotropin it will be critical that the feeding management program maximizes dry matter intakes. Treated cows must be offered and consume more of

TABLE 3. Feed Intake Somatotropin Treatment[1].

	Dry Matter Intake (% Body Weight)
Pretreatment (2 weeks)	3.9%
During treatment (weeks 9-11)	
Controls	4.0%
bGH	4.6%

Bauman, Eppard, DeGeeter and Lanza, 1985.

[1] Somatotropin injected daily from 84 to 272 days after calving (188 days).

balanced ration in order to support the higher level of milk production. Nutritional management practices must ensure that nutrient reserves are restored during late lactation and dry cow management must be superior to ensure optimal response to somatotropin.

Somatotropin treatment for 38 weeks of one lactation at dose levels likely to be approved for commercial use and under the excellent management conditions of these studies did not appear to affect either cow health or reproductive performance. Cows became pregnant, and delivered normal, healthy calves at term. They replenished body reserves in late lactation. Multi-lactation studies with larger numbers of cows will be required to confirm the safety of somatotropin treatment, but under excellent management will continue to be the key factor in maintaining a healthy, reproductively efficient herd.

Somatotropin — The Bottom Line

New breakthroughs in biotechnology have permitted studies on the potential commercial application of somatotropin administration to increase milk production efficiency. Experiments in which somatotropin has been administered for up to 260-270 days during a single lactation suggest that production increases of up to 25% on a full-lactation basis can be expected. It's important to keep in mind that somatotropin increases the efficiency of production by a mechanism that is identical to that of other technologies like improved feeding management, mastitis control and generic selection. All permit the production of more milk (and more profit) at a fixed animal maintenance cost.

Many questions remain regarding the use of somatotropin in commercial herds. Much more university and field research will be needed.

- Response in the field under various environments and management conditions is unknown. Herd responses are likely to vary from 0% to 25% depending upon the level of herd (especially nutritional) management.
  It seems reasonable to expect increases of 10-15% in the national milk supply with widespread use of somatotropin.
- Response in herds where management is marginal is not known. There could be no production response, a short-lived production response or possibly even a negative response in terms of health and reproduction. Top quality herd management will definitely be critically important to realizing the benefits of somatotropin. Somatotropin is not a magic bullet.
- At present, daily injections of somatotropin are required. However, the development of a "slow release"injection form that would require much less frequent injection is the subject of intense investigation. Success is expected.
- Date of commercial availability is not known. It will depend in part upon FDA approval, which is not expected before the end of the decade.
- Economical production of large quantities of somatotropin is possible. Research by Cornell economists and engineers estimated a production cost of $.09-$.17 per daily dose depending on plant size. The sale price has not been estimated, but it will be higher due to costs for research and development, marketing distribution etc. (4).
- Cornell research indicates that the application of this technology will be profitable (4, 7). In that study the use of somatotropin in a herd averaging 16,000# of milk was projected to increase income over feed cost by $114 ($11 per cwt milk price net of marketing costs) if production increased 12.8%. If a 25% increase in production were attained, the increase in income over feed cost would be $204. These figures represent the additional dollars that would be available to purchasing the somatotropin, paying any expenses associated with its use in the herd and profit.
- A survey of producers suggests that they will be very willing to try somatotropin. Twenty-seven percent expected to try the product on at least some of their cows immediately, with 66% trying it within one year. Long term use (adoption) in herds will depend on the production response obtained, all costs associated with its use and the method of administration.
- Production increases (10-15% in the aggregate) due to the application of this new technology will likely result

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in a decline in milk prices reducing the short-term gain in farm returns. The number of producers and the size of the national dairy herd will decline as it has in the past as the market has sought a new equilibrium. The size of this adjustment and its timing will depend not only on the production response and the rate of adoption of the technology but also on government dairy policy (price supports, production controls etc.).

Dairy farmers have time to prepare for somatotropin. They and their advisors should become as knowledgeable as possible about the product and seek counselling when necessary about how the technology can be profitably implemented. Even without the approval of somatotropin adjustments must certainly occur in the dairy industry. It's now time to evaluate farm businesses in light of today's conditions and consider alternatives where necessary. Those planning to continue must fine-tune all areas of management. The goal must be to effectively utilize today's technology and management recommendations to maximize efficiency. Outstanding herd, crop and financial management will continue to set the top dairy farmers apart. Management will be more critical in the future than it is today as the new technology becomes available.

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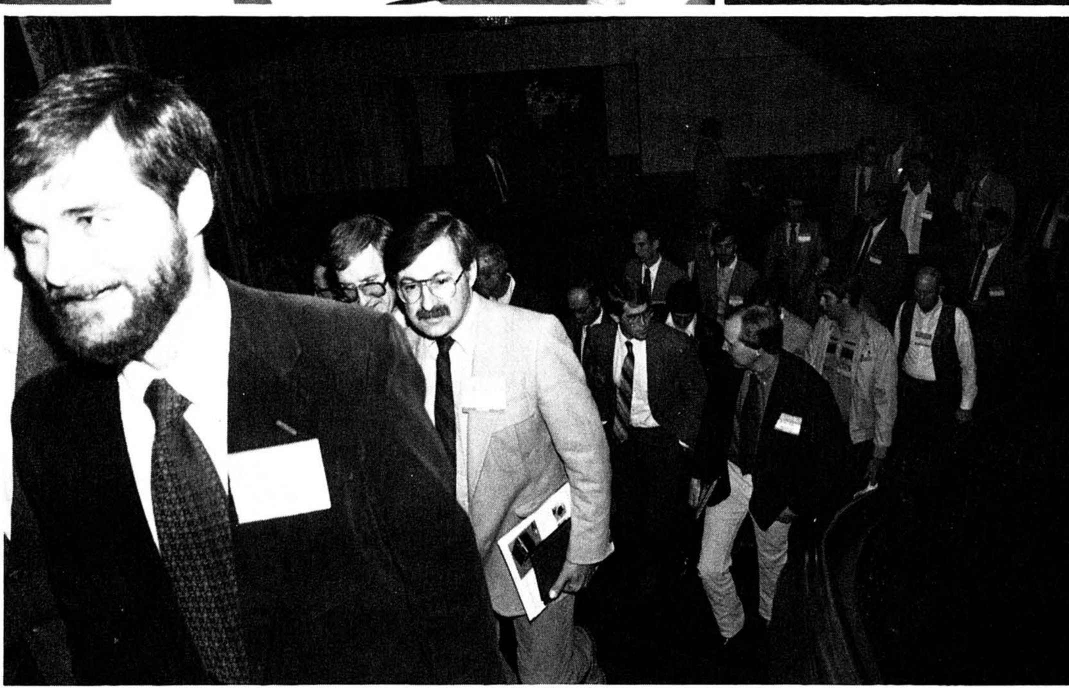

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