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Technology Adoption: 2002 rbST Survey of California Dairy Industry

Introduction

Bovine somatotropin is a naturally occurring (peptide) hormone produced in the pituitary gland of cows. It was discovered in the 1920's, and originally called "bovine growth hormone" or BGH. Experiments in the 1930's revealed that BGH, when extracted from the pituitary gland of a cow and injected into another cow, could increase milk production in the recipient cow. (According to Monsanto, it takes the pituitaries of 25 cows to get enough BST to dose one cow for one day). In the late 1970's, Dr. Dale Bauman, an animal scientist at Cornell University, successfully transferred the gene responsible for BGH production (in a cow) to a bacterium. The resulting product was called recombinant Bovine Growth Hormone, or rBGH. Simple multiplication of the bacterium meant that it could easily be produced in commercial quantities at very reasonable cost. Several pharmaceutical and non-pharmaceutical companies became very interested in the product in the early 1980's. Despite the fact that rBGH is a peptide hormone and not a (much-maligned) steroidal hormone, to avoid the stigma associated with hormones, the industry agreed to change its name to Bovine Somatotropin. Thus, it's synthetic analog would be called recombinant Bovine Somatotropin, or rbST. Today, both names (rBGH and rbST) are still used.

Four companies involved in rbST research applied for patents for their particular brand of rbST in the early 1980's, which resulted in many misstatements, exaggerations and misunderstandings. Congressional Hearings were held in June 1986. From these hearings emerged the alleged last word on rbST. The basic findings were:

- rbST, when injected into a cow, could cause a 10 to 25 percent increase in milk production.
- There was also a 10-15 percent increase in feed efficiency. This means that there is an effective decrease in feed costs per unit of milk produced, and therefore a lower average cost of production.
- rbST appeared to be safe both for human milk consumption and for cows.

It took until November of 1993 to gain FDA approval, and it was not released commercially until February of 1994. However, the controversy surrounding rbST that has existed since 1983, continued. Specifically, questions were raised about adverse health effects on animals treated with rbST, the appropriateness of the technology for an industry plagued with surpluses, the effects of increased milk production on milk prices, and the plight of the family farm in the U.S. Media hype about the impacts of rbST has been intermittent since 1983, but increased substantially from 1988 - 1993.

2002 rbST Survey

Survey was sent to 1739(??) dairy producers in California.

A total of 524 responses were received.

Regions in survey and number sent and responses by region???

Basic Characteristics of dairies in survey

Table 1. Basic characteristics of dairies responding to the survey.

	Average	Std. Dev.	Min	Max	Count
Number of cows	915	851	20	5000	512
Milk Production (lbs/cow)	21864	3473	9150	30800	472
Age of Operator (yrs)	47.5	11.1	<30	>60	515
Education Level (index)	3.11	1.43	0	6	505
Years of Operation (yrs)	24.3	13.0	1	60	496
Cost of Production* ($/cwt)	9.61	3.23	0	13.10	476
Feed cost (% of cost of prod)	49.2	9.0	15	85	455
Milkings per day	2.12	0.32	2	3	520

* Not complete – missing values

Table 1 lays out the average characteristics of the dairies and dairy producers who responded to the survey in January 2002. However, a single table, like Table 1, is insufficient to describe all of the characteristics of the dairies and the producers who own and manage them. The following brief descriptions of the background characteristics of the survey respondents and their operations is intended to give the reader a clearer picture of the background data underlying the survey.

a. Number of Cows:

While the average number of cows for the survey sample is 915, the size distribution of dairies, both in our survey and in California, is highly skewed. The smallest dairy in the survey sample has 20 cows while the largest has 5000. The sample contains 11 dairy operations with less than 100 cows and 6 dairies with more than 4000 cows (4 have 5000 cows). As the following table (Table 2) shows, 41 percent of the dairies in the sample are less than 500 cows and 71 percent of the sample lies between 0 and 1000 cows.

Table 2: Frequency Distribution of Cow Numbers

Number of cows	# of dairies	% of sample
0 – 500	209	41
501 – 1000	153	30
1001 – 1500	61	12
1501 – 2000	42	8
2001+	47	9
Total	512	100

Another way to look at the skewness of the distribution of cow numbers in the survey sample is to examine the percentiles of cow numbers. Table 3 shows that the median of the sample (the point at which 50 percent of all cows in the sample lie below, and 50 percent lie above) is 630. If we take 25 percent either side of the median (50 percent of the sample), we see that this includes all dairies from 350 cows to 1200 cows. **[Probably should change Table 2 to reflect these numbers]**

Table 3: Percentiles of Cow Numbers

Percentile	# of Cows
5%	140
10%	200
25%	350
50%	630
75%	1200
90%	2700
95%	4022

[Comparison to California numbers – see Don Shipplehoute]

b. Milk Production

Average milk production per cow in California in 2001 was 20,900 lbs. The average production per cow in our sample is 21,864, therefore our sample represents a slightly higher average production unit than the average California dairy. According to the standard skewness and kurtosis figures (-6.6 and 4.2 respectively), our sample is outside the bounds of a normal distribution. The smallest milk production per cow is 9150 lbs. while the largest is 30,800. **[Check these numbers]** Nevertheless the sample is relatively evenly distributed around the mean. **[Table here??]**
[Compare to California figures]

c. Age of Operator

We asked respondents to indicate their age group according to 4 categories; under 30 years old, 30-45 years, 45-59, and 60 years and over. We then arrived at an average age of 47.5 by taking the mode of the middle two groups and assigning 25 and 65 respectively to the other two groups. The actual frequency distribution of age groups is shown in Table 4.

Table 4: Frequency Distribution of Age Groups

Age Group	Number of Respondents	% of Respondents
< 30	22	4.3
30 – 45	199	38.6
45 – 59	203	39.4
>60	91	17.7
Total	515	100

d. Education

Respondents were asked to indicate their level of education according to the 6 levels indicated in Table 5. The mean education level of 3.11 reported in Table 1 indicates that the average respondent to this survey had some college education. About 58% of our sample have a high school diploma or some college level education. Over a quarter of the respondents have a bachelors or graduate degree.

Table 5: Distribution of Education Levels

Index	Education Level	# of Respondents	% of respondents
0	No education	4	1.0
1	Some high school	43	8.5
2	High school diploma/GED	161	31.9
3	Some college	133	26.3
4	Associate degree	35	6.9
5	Bachelors degree	105	20.8
6	Graduate degree	24	4.8
Total		505	100.0

e. Years of Operation

We asked respondents to indicate the number of years they had operated a dairy. Some respondents answered with very large numbers, much higher than their age group. We suspect that they were reporting how long their family had been in dairying, or how long the farm had been in the family, rather than the length of time the respondent had been dairying. Nevertheless, the average number of years of operating a dairy was 24.3, with a fairly large standard deviation. Several respondents were fairly new to dairying, while others had been dairying for 50 years or more. The largest category of responses was between 25 – 30 years (17%), while some 45% of respondents had been operating a dairy between 15 and 30 years.

f. Cost of Production **[Assign missing values and re-evaluate]**

g. Feed Costs

Respondents were asked to indicate approximately what percentage of total cost of production is represented as feed costs. The rule of thumb is that about 50% of total costs are due to feed expenses. The survey sample average of 49.2% bears this out, although feed costs reported ranged from a low of 15% to a high of 85%. Significantly however, 50% of respondents reported feed costs between 45 – 55% of total costs.

Table 6: Distribution of Feed Costs as a % of Total Costs.

Feed Costs as % of Total Cost	% of Respondents
<40%	14
40 – 45%	19
45 – 50%	35
50 – 55%	15
>55%	17

h. Number of Daily Milkings.

Respondents reported how many times a day they milk their cows. The vast majority milk twice a day, with only about 12% of respondents reporting that they milked 3 times a day. No one reported milking any more than 3X.

Technologies Used on Dairies

Theory suggests that those who have adopted technology in the past more often easily adopt new technologies. Therefore, our survey asked respondents to indicate the relevant dairy technologies that they had adopted in the past as an indicator of their willingness to adopt rbST. Table 7 reports the percentage of respondents who have adopted relevant dairy technologies in the past.

Table 7: Dairy technologies adopted by survey respondents.

	Percent of Respondents	Count
Personal Computer	80.0	516
Artificial Insemination	88.4	516
Total Mixed Rations	77.5	516
On-farm Diagnostic Tests	29.5	516
Silage Additives	43.7	515
Feed Buffers	70.9	516
Other Technologies	9.1	232

Monitoring of Milk Yields and Feed Use

In order to evaluate the cost effectiveness or feasibility of adopting a new technology like rbST, dairy producers need to monitor changes in both milk yield and in feed intake. Increased milk yields due to the use of rbST require increases in feed to sustain the cow, otherwise the cow loses body condition and may develop other complications such as breeding and reproductive difficulties. Past research has shown that while most producers are easily able to monitor increases in milk yield with modern technology, accurately monitoring the feed intake of individual cows is much more difficult. We asked respondents to indicate whether or not they actually monitor milk yields and feed intake, and how they do it. Table 8 reports the percentage of respondents who monitor milk yield and feed intake, and at which levels they monitor them.

Table 8: Percentage of respondents who reported monitoring milk yield and feed intake, and the level at which they monitor them.

	Percent of Respondents	Count
Monitor Milk Yield	96.3	519
Whole Herd Milk Yield	78.6	518
Milk Yield by String	37.6	518
Individual cow – monthly	75.5	518
Individual cow – daily	19.1	518
Monitor Feed Intake	91.5	516
Whole herd feed intake	57.7	515
Feed intake by string	66.6	515
Individual cow feed intake	12.0	515

Use of rbST on California Dairies

Current Status on Use of rbST

Survey respondents were asked to classify themselves into one of 4 groups; regular users of rbST, irregular users, respondents who might use rbST in the future, and those who will never use rbST. This classification of technology adopters has emerged as a useful one because it is easily understandable by dairy producers, and it allows us to observe the essential differences between the various groups. Regular users of rbST are those who have chosen to adopt the new technology as a useful tool to increase productivity, milk yield and profitability or may use it as a management tool for a variety of purposes. Irregular users of rbST include those who have tried the new technology and either not yet adopted it fully into their management of the dairy, or, are not satisfied that the new technology is feasible for their dairy operations for a variety of reasons. In many cases, these irregular users of rbST may have, or may be in the process of, **disadopting** the new technology. Respondents who classified themselves as "might use in the future" include dairy producers who have decided at this stage not to adopt the new technology, but are prepared to keep an open mind about using it in the future. Some of these respondents may be committed non-users, but feel that they may be forced to use rbST in the future to remain competitive, while others may simply be producers who have not yet had an opportunity to experiment with rbST. Finally, respondents who classified themselves as "will never use rbST" are the committed non-users of this new technology. Given the controversy that has surrounded rbST in the past, both inside and outside the dairy industry, many dairy producers feel that this technology is not an "appropriate" technology for the dairy industry. In addition, many creameries have asked their dairy producers not to use rbST, and some creameries ask producers to sign an affidavit attesting to the non-use of rbST.

Table 9: Classification of 524 respondents into 4 groups according to their status as users of rbST as of January 2002.

	Number of Responses	Percent of Total
Regular Users	143	27.3
Irregular Users	93	17.8
Might Use in the Future	46	8.8
Will Never Use rbST	242	46.2
Total Responses	**524**	**100**
Users	236	45
Non-users	288	55

Table 9 shows how the 524 respondents to our survey classified themselves into the 4 groups. Approximately 27% classified themselves as regular users of rbST, and approximately 18% classified themselves as irregular users. About 9% of respondents said they might use rbST in the future, and about 46% said they would never use the new technology. The two groups, "users" and "non-users", are useful additional classifications. Users include both regular and irregular users, while non-users include both those who will never use rbST and those who might use it in the future.

Based on this classification, and assuming the survey sample is representative of the California dairy industry as a whole, we can conclude that about 45% of California dairy producers are users of rbST, while about 55% are non-users.

Decision Years

Respondents were asked in which years they made decisions about their use, or non-use, of rbST. In the case of regular and irregular users, they reported the year in which they began to use rbST. For those who said they might use rbST in the future, they were asked when they would begin to use the new technology. In the case of the committed non-users, they were asked in which year they decided *not* to use rbST. In each case, the time of making the decision is an interesting insight into the relative commitments that dairy producers have made given the controversy that has surrounded the new technology. Unfortunately, irregular users were not asked whether they had stopped using rbST, and if so, why and when. Similarly, committed non-users were not asked if they had previously used rbST, and if so, why and when they stopped using it. Nevertheless, the following tables offer some insight into the decision-making processes that dairy producers have undergone with respect to rbST.

In the following tables, 1994 is identified as a pivotal year with respect to rbST, because that is the year that rbST first became commercially available.

a. Regular Users of rbST.

Many regular users of rbST apparently decided to use rbST in 1994 when it first became commercially available. A few producers were obviously involved in trials prior to 1994, but the majority of regular users appear to have adopted rbST in a steady, but dwindling stream from 1994 to the present.

Table 10: Years when Regular Users of rbST made decision to use.

Year	# of users	Percent of users	Cumulative %
<1994	5	3.5	
1994	42	29.4	32.9
1995	15	10.5	43.4
1996	21	14.7	58.0
1997	12	8.4	66.4
1998	22	15.4	81.8
1999	15	10.5	92.3
2000	6	4.2	96.5
2001	5	3.5	100.0
Total	143	100.0	

[Should we also indicate the percentage of the total sample in the table??]

b. Irregular Users of rbST

Like the regular users, irregular users appear to have decided to begin using rbST around 1994 and 1995. Unlike regular users however, the number of additional irregular

users has declined more rapidly over the years since 1998. It is not clear however, how many of these respondents have disadopted rbST, or are in the process of doing so.

Table 11: Years when Irregular Users of rbST started to use.

Year	# of users	Percent of users	Cumulative %
<1994	3	3.3	
1994	17	18.5	21.7
1995	22	23.9	45.7
1996	4	4.4	50.0
1997	10	10.9	60.9
1998	13	14.1	75.0
1999	9	9.8	84.8
2000	9	9.8	94.6
2001	4	4.4	98.9
2002	1	1.1	100.0
Total	92	100.0	

c. Might use rbST in the future

Respondents who classified themselves as "might use in the future" are clearly not planning to use rbST in the very near future. The vast majority of respondents indicated that they *might* start to use rbST more than a year from now.

Table 12: Time when "might use" respondents might begin to use rbST.

Might begin in:	# of users	Percent of users	Cumulative %
1 month	2	4.7	
3 months	2	4.7	9.3
6 months	4	9.3	18.6
1 year	5	11.6	30.2
> 1 year	30	69.8	100.0
Total	43	100.0	

d. Committed non-users, who will never use rbST.

The vast majority of committed non-users appear to have made their decision **not** to use rbST in 1988 and in 1994. It is not clear what the significance of 1988 was, but fully 70 respondents (33%) decided in that year not to use rbST. Another 71 respondents (33%) decided not to use rbST in 1994, the year that it became commercially available. By 1996, more than 80% of the 212 committed non-users who answered this question had decided not to use the new technology. Once again, it not clear how many of these respondents have tried rbST in the past and decided to disadopt it. **[Check comments]** But it is very clear that a large number of dairy producers made their decision not to use this technology well before the commercial availability of rbST.

Table 13: Year in which committed non-users of rbST decided not to use rbST

Year	# of users	Percent of users	Cumulative %
1988	71	33.0	
<1994	86	33.0	73.6
1995	12	5.7	79.3
1996	5	2.4	81.6
1997	11	5.2	86.8
1998	13	6.1	92.9
1999	9	4.3	97.2
2000	2	1.0	98.1
2001	2	1.0	99.1
2002	2	1.0	100.0
Total	212	100.0	

Basic Characteristics of Dairies by Status on rbST Use

Table 14: Basic characteristics of dairies responding to the survey by status on rbST use.

	Regular	Irregular	Might Use	Never Use
Number of cows	1391	907	772	658
Milk Production (lbs/cow)	23425	21671	21477	20962
Age of Operator (yrs)	44.2	44.3	47.6	50.8
Education Level (index)	3.5	3.2	3.4	2.8
Years of Operation (yrs)	21.2	22.0	23.2	27.4
Cost of Production* ($/cwt)	10.66	10.69	8.69	8.67
Feed cost (% of cost of prod)	47.6	49.4	48.8	50.3
Milkings per day	2.21	2.15	2.08	2.04

* Not complete – missing values

Many of the basic characteristics reported in Table 14 display some of the classic theoretical principles of technology adoption. For example, theory suggests that technologies are generally first adopted by larger, more productive enterprises whose managers are younger, with a higher level of education and who tend to adopt other technologies more willingly than their older peers. Most of the characteristics reported in Table 14 tend to confirm this theoretical premise. However, while it would be easy to simply let it go at that and press on to other interesting aspects of the survey, theory also suggests that we delve deeper into the underlying characteristics to discover their true significance. The following analysis presents a more comprehensive picture of the differences between the operations and their owner/managers with respect to their use or non-use of rbST.

a. Number of Cows by rbST Use Status

Theory and previous research suggests that new technologies like rbST will be adopted initially by entrepreneurs with larger enterprises. A brief examination of Table

15 would tend to confirm this. Regular users of rbST have, on average, larger enterprises than do the dairy operations representing the other categories of (lesser) rbST use. Furthermore, irregular users of rbST have larger enterprises on average than their non-using peers. Even those who reported that they might use rbST in the future have slightly larger enterprises than those who are committed non-users. However, as shown in Table 15, some relatively small enterprises have also adopted rbST. **[Need to provide Std Deviations as well as some frequency stats to back this up]** It is also true that some very large enterprises belong to each of the other categories, including the confirmed non-users. So to assume that most large enterprise would be expected to have adopted rbST, or alternatively, that smaller dairies would not adopt rbST, is not always true.

Table 15: Number of Cows by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular	142	1391[a]	1000	120	5000
Irregular	90	907[b]	865	20	5000
Might Use	46	772	784	50	3783
Never Use	234	658	609	38	5000
Total/Ave	512	915	851	20	5000

a = significantly different from other 3 groups; b= significantly different from "Never Use"

A one-way Analysis of Variance (ANOVA) was used to test whether the differences between the means are statistically significant. The F-test for the ANOVA was 25.57 and the P-value was 0.0000, indicating that there is a statistically significant difference between the means of number of cows. Using Fisher's least significant difference (LSD) procedure at the 95% level, the test shows that there is a statistically significant difference between the means of the regular users and the other three groups. It also showed that there is a statistically significant difference between the means of the irregular users and the committed non-users. However, there is no significant difference between the means of the irregular and "might use" groups, nor between the "might use" group and the committed non-users. Because there are a number of outliers in the sample, the ANOVA test was confirmed by a Kruskall-Wallis test for medians at the 95% level. (A variance check however, shows that there are statistically significant differences between the standard deviations of the groups at the 95% level, and this may invalidate the ANOVA).

b. Milk Production by rbST Use Status

As with the previous variable, milk production means reported in Table 14 would appear to display significant differences between the 4 groups, with the regular users showing higher milk production per cow than the other groups. In addition, irregular users show higher average milk production than the "might use" group and the committed non-users. And the "might use" group shows slightly higher average milk production than the committed non-users.

Table 16: Milk Production per cow by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular	139	23425[a]	2794	16000	30800
Irregular	87	21671	3467	13369	28500
Might Use	42	21477	3279	12200	27500
Never Use	204	20962	3590	9150	30000
Total/Ave	472	21864	3473	9150	30000

a = significantly different from other 3 groups

A one-way Analysis of Variance (ANOVA) was used to test whether the differences between the means are statistically significant. The F-test for the ANOVA was 15.51 and the P-value was 0.0000, indicating that there is a statistically significant difference between the means of milk production per cow. Using Fisher's least significant difference (LSD) procedure at the 95% level, the test shows that there is a statistically significant difference between the means of the regular users and the other three groups. However, there is no significant difference between the means of the irregular, "might use" groups, and the committed non-users. Because there are a number of outliers in the sample, the ANOVA test was confirmed by a Kruskall-Wallis test for medians at the 95% level.

c. Age of Operator by rbST Use Status

Once again, there appear to be differences in the age of the operator that follow the classic theoretical case of technology adoption, with younger operators tending to adopt rbST more readily than their older peers. A One-way ANOVA to test the differences in the means of age of operator yields an F-test of 15.04 with a P-value of 0.0000, indicating a statistically significant difference between the means. However a Fishers LSD procedure shows a significant difference in age only between the regular and irregular users, and the committed non-users group.

Table 17: Age of Operator by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular	142	44.2[a]	10.2	25	60
Irregular	93	44.3[a]	10.5	25	60
Might Use	45	47.6	11.2	25	60
Never Use	235	50.8	10.8	25	60
Total/Ave	515	47.5	11.1	25	60

a = significantly different from the "never use" group

d. Education by rbST Use Status

As with age groups, there appear to be differences in the level of education of the operator that follow the classic theoretical case of technology adoption where those operators with a higher level of education tend to adopt rbST more readily than their peers. A One-way ANOVA to test the differences in the means of level of education of operator yields an F-test of 8.51 with a P-value of 0.0000, indicating a statistically significant difference between the means. However a Fishers LSD procedure shows a

significant difference in level of education only between the regular, irregular users and the "might use" group, and the committed non-users group.

Table 18: Education of Operator by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular	141	3.5[a]	1.4	1	6
Irregular	92	3.2[a]	1.4	1	6
Might Use	45	3.4[a]	1.5	0	6
Never Use	227	2.8	1.4	0	6
Total/Ave	505	3.11	1.4	0	6

a = significantly different from the "never use" group

e. Years of Operation by rbST Use Status

In many ways, the years of operation mirrors the age distribution of the survey sample, since younger operators could hardly be expected to operate a dairy longer than their older peers. This assumption is confirmed by the ANOVA test of years of operation. The ANOVA F-test was 8.18 with a P-value of 0.0000. The only statistically significant differences between the groups are the same as the age of operator variable.

Table 19: Years of Operation by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular	141	21.2[a]	11.6	1	53
Irregular	91	22.0[a]	11.0	2	50
Might Use	44	23.2[a]	12.7	1	60
Never Use	220	27.3	13.9	1	60
Total/Ave	496	24.3	13.0	1	60

a = significantly different from the "never use" group

f. Cost of Production by rbST Use Status **[Fill in missing values and rexamine]**

Table 20: Cost of Production by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular					
Irregular					
Might Use					
Never Use					
Total/Ave					

g. Feed Costs by rbST Use Status

Average feed costs as a percentage of total cost of production do not appear to be significantly different from each other for the 4 groups. An ANOVA test confirms this, although the Fisher LSD procedure reveals that there is a statistically significant difference between the feed costs of regular users and those of the committed non-user group.

Table 21: Feed Costs by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular	132	47.6[a]	6.8	30	70
Irregular	81	49.4	7.4	25	70
Might Use	44	48.8	9.0	25	75
Never Use	198	50.3	10.7	15	85
Total/Ave	455	49.19	9.0	15	85

a = significantly different from the "never use" group

h. Daily Milkings by rbST Use Status

Since 3X milking could be construed as a dairy technology, then we might expect that dairy producers who have adopted 3X milking would tend to be more likely to also be early adopters of rbST. In addition, according to many dairy producers, the management of a dairy operation associated with 3X milking is quite similar to the management required when rbST is used. Therefore, those who have adopted 3X milking may also more easily adopt rbST. While the average daily milkings reported in Table 22 do not appear to be significantly different between the 4 groups, the higher average number of daily milkings of the regular users group would indicate that more producers in that group milk 3X than in the other groups. Not surprisingly then, an ANOVA F-test of the difference in the means of the 4 groups was 9.6 with a P-value of 0.0000, indicating that there is some significant difference between the means. A Fishers LSD procedure reveals that there is a statistically significant difference between the means of the regular users, and the "might use" group and the committed non-users. There is also a significant difference between the irregular users and the committed non-users group.

Table 22: Daily Milkings by rbST Use Status

	Count	Average	Std. Dev.	Min	Max
Regular	142	2.21[a]	0.41	2	3
Irregular	93	2.15[b]	0.36	2	3
Might Use	46	2.08	0.28	2	3
Never Use	239	2.04	0.21	2	3
Total/Ave	520	2.11	0.32	2	3

a = significantly different from the "might use" and "never use" group; b = significantly different from the "never use" group

Use of Technologies by rbST Use Status

As indicated previously, theory suggests that those who have adopted technology in the past more often easily adopt new technologies. Table 23 reports the use of certain dairy technologies by rbST use status. A chi-square test is used to determine whether the difference between the rbST use groups is statistically significant. Three of the variables are highly significant. The use of a personal computer for record keeping and other dairy operation related tasks appears to be a highly significant technology associated with those who have adopted rbST. As expected, the use total mixed rations (TMR) and feed buffers are also significant precursors to the use of rbST (Henriques and Butler, 2000). While artificial insemination is used by a large majority of the dairy industry, it also is a relatively significant predictor of rbST use according to the chi-square test. Finally, silage

additives also appear to be somewhat significant in determining differences between regular users of rbST and non-users.

Table 23: Dairy Technologies Adopted by Survey Respondents by rbST Use Status

	Regular	Irregular	Might Use	Never Use
Personal Computer***	94	91	83	67
Artificial Insemination**	94	90	93	84
Total Mixed Rations***	92	82	83	66
On-farm Diagnostic Tests	27	31	22	31
Silage Additives*	53	38	43	40
Feed Buffers***	85	78	80	58
Other Technologies	8	10	N/a	n/a

* indicates the significance of a chi-square test for the difference between the variable and rbST use status
*** = significant at the 99% level; ** = significant at the 95% level; * = significant at the 90% level

Monitoring of Milk Yield and Feed Intake by rbST Use Status

Increased milk yields created by the use of rbST require increases in feed to sustain the cow. Therefore both milk yields and feed intake need to be monitored by producers who use rbST. Most producers are easily able to monitor increases in milk yield with modern technology, but accurately monitoring the feed intake of individual cows is much more difficult. Table 24 reports on the percentage of respondents who indicated whether they monitor milk yields and feed intake, and at what levels they monitor them, by rbST use group. Once again, a chi-square test is used to determine whether the difference between the rbST use groups is statistically significant.

Table 24: Percentage of respondents who reported monitoring milk yield and feed intake, and the level at which they monitor them, by their rbST Use Status.

	Regular	Irregular	Might Use	Never Use
Monitor Milk Yield	99	95	100	95
Whole Herd Milk Yield**	82	67	80	81
Milk Yield by String	31	38	37	41
Individual cow – monthly	75	71	83	76
Individual cow – daily	17	21	11	21
Monitor Feed Intake	90	90	96	92
Whole herd feed intake***	52	47	57	66
Feed intake by string**	74	71	70	59
Individual cow feed intake**	5	13	13	16

* indicates the significance of a chi-square test for the difference between the variable and rbST use status
*** = significant at the 99% level; ** = significant at the 95% level

The table yields some surprising results. Not surprisingly, since most producers monitor milk yields at some level, there is very little statistical significance associated with monitoring milk yields between the groups. However, a chi-square test reveals that there is a statistical significance associated with rbST use and monitoring milk yields at the whole herd level. Since the only group that shows any real difference from the others is the irregular users group, it is suspected that this is a statistical anomaly **[but why??]**.

More surprising are the statistical results associated with each of the 3 levels of monitoring feed intake. Contrary to expectations, it would appear that a larger percentage of the committed non-users group monitor feed intake at the whole herd level and at the individual cow level, than the other 3 groups. And these are statistically significant at the 99% and 95% level respectively. Regular users, on the other hand, seem to monitor feed intake at the level of the string, which is consistent with adopting TMR, and monitoring a separate rbST string.

Decisions about the Use of rbST

a. Percentage of Herd Treatment

Respondents who classified themselves as regular or irregular users were asked to indicate the percentage of the herd that they first treated with rbST and the percentage of the herd that are currently being treated with rbST. They were also asked to indicate if they were planning to change the percentage of the herd that is being treated with rbST and, if so, to how much. In addition, respondents who classified themselves as "might use in the future" were asked to indicate what percentage of the herd they would first treat with rbST. Table 25 reports the percentage of respondents herds treated with rbST and their plans to change them, by rbST use status.

Table 25: Average percentages of respondent's herds treated with rbST and plans to change them, by rbST Use Status

	Regular	Irregular	Might Use	Count
% of herd first treated with rbST	38	31	35	247
% of herd currently on rbST	51	6	n/a	234
Plan to change % of herd on rbST? (% yes)	20	5	n/a	234
What % of herd change to?	30	3	n/a	30

While the average percentages of herds first treated with rbST are remarkably close, the ranges reported are very wide as the statistics shown in Table 26 verify. We have included the median and the lower and upper quartiles to give the reader a better idea of the extremes of the sample data. The upper and lower quartiles are the bounds for the 50% of the sample population around the median. As shown in Table 26, regular users first treated a higher percentage of their herds than did irregular users. Interestingly, the "might use" group appears to feel that they would treat a higher percentage of their herds than the irregular users actually did.

Table 26: Percentage of respondents herds first treated with rbST, by rbST Use Status

	Count	Average	Std. Dev.	Min	Max	Median	Lower Q	Upper Q
Regular	140	38	21	5	100	40	20	50
Irregular	91	31	19	1	100	30	15	40
Might Use	16	35	23	5	100	30	20	50
Total/Ave	247	35.4	21	1	100	30	20	50

In contrast to the average percentage of the herds first treated with rbST, the difference in the current average levels of treatment between regular and irregular users are extreme, to say the least. Regular users are currently treating an average of 51% of their herd with rbST, with 50% of the respondents falling between 40% and 60% of the herd. Irregular users are currently treating an average of 6% of their herd with rbST, with 50% of the respondents falling between 0% and 10%. The median of irregular users is 0, indicating that at least 50% of the respondents in this group are not currently using rbST, and may in fact have disadopted it. In general, regular users have increased their usage of rbST from an average of 38% of their herd to an average of 51%. Irregular users have significantly decreased their use of rbST from an average of 31% of their herd to an average of 6%. A significant number of irregular users have reduced their current usage to 0, adding credence to the assumption that many of the irregular users have disadopted the technology.

Table 27: Percentage of respondents herds currently being treated with rbST, by rbST Use Status

	Count	Average	Std. Dev.	Min	Max	Median	Lower Q	Upper Q
Regular	143	51	18	0	100	55	40	60
Irregular	91	6	10	0	50	0	0	10
Total/Ave	234	33.6	27	0	100	35	4	60

Tables 28 and 29 present the responses to questions about whether respondents plan to change the percentage of their herds that they treat with rbST, and, if so, to what percentage. Only about 20% of regular users and about 5% of irregular users said that they plan to change the percentage of their herd that is treated with rbST. Interestingly, the majority of both regular and irregular users who plan to change their use of rbST plan to *reduce* the percentage of their herds that they treat with rbST, thus providing further evidence that some producers are in the process of disadopting the new technology.

Table 28: Percentage of respondents who plan to change the percentage of their herd that is treated with rbST, by rbST use status

	Count	# of Respondents	% of respondents
Regular	143	28	19.6
Irregular	91	5	5.5
Total/Ave	234	33	14.1

Table 29: Percentage of herd that respondents plan to treat with rbST in the future, by rbST Use Status

	Count	Average	Std. Dev.	Min	Max	Median	Lower Q	Upper Q
Regular	25	30	17	0	60	30	20	40
Irregular	5	3	4	0	10	0	0	5
Total/Ave	30	25.7	19	0	60	28	10	40

b. Factors considered in deciding to use rbST

Regular and irregular users of rbST were asked what factors played a major role in their decision to use rbST. In addition, respondents who classified themselves as

"might use in the future" were asked what factors *would* play a major role in their decision to use rbST. Table 30 reports the percentage of respondents who indicated the various factors that played, or would play, a role in their decision to adopt rbST. For regular users, increased milk production, use of rbST as a management tool, and increased profit were the factors that played a major role in their decision to use rbST. The same factors were also somewhat important for irregular users, but a higher percentage reported that factors other than the ones listed were also important. For those respondents who classified themselves as "might use in the future", using rbST as a management tool and "other" factors will play the most important role in making their decision to use rbST. **[Need to enumerate and evaluate "other" factors]** A significant number of "might use" respondents indicated that positive feedback from other producers would play a role in their decision to use rbST. A chi-square test reveals that all factors considered were statistically significantly different for each of the groups at either the 95% or 99% level.

Table 30: Factors that played a major role in the decision to use rbST.

	Regular	Irregular	Might Use	Count
Increased Milk Production***	77	66	38	280
Management Tool**	60	42	53	280
Opinion of other producers**	7	9	22	280
Increased profit***	73	42	n/a	235
Other factors***	12	18	36	280

* indicates the significance of a chi-square test for the difference between the variable and rbST use status
*** = significant at the 99% level; ** = significant at the 95% level

c. Factors considered by **committed non-users** to NOT use rbST

Respondents who classified themselves as committed non-users were also asked what factors played a major role in their decision *not* to use rbST. These results are displayed in Table 31. No single set of responses appears to be a dominant one. However a large number of committed non-users indicated that negative feedback from other producers was a major factor, along with others. **[Does this mean that some producers are being subjected to peer pressure not to use rbST??]**

Table 31: Factors considered by committed non-users to not use rbST.

	Percent "yes" Response	Count
Not Cost Effective	34	233
Not good management tool	29	233
Negative feedback from other producers	36	233
Other	44	233

d. Decision on which cows to treat with rbST

Regular and irregular users were asked to indicate how they decided which cows on which to use rbST. Responses to this question are obviously influenced by how dairy producers use rbST, or for what purpose they use it. For example, some producers may use rbST only on a select number of cows for management purposes (i.e. older cull cows, health reasons), while others may use rbST on cows that they consider can handle the

treatment and/or on whom rbST would be cost effective. **[This calls for a much more detailed examination of the factors and characteristics that surround any particular respondent]**

For regular users, days in milk clearly emerges as the dominant factor in deciding which cows on which to use rbST. But depending on the reasons for using rbST, other factors may also be important in deciding which cows to treat. **[This entire issue needs to be examined in much more detail]**

Table 32: Deciding factors on which cows to use rbST, by rbST use status (Percentage of Respondents)

	Percentage of Respondents		
	Regular	Irregular	Count
All cows	4	3	230
Milk production/cow*	37	25	230
Days in Milk***	73	43	230
Body condition/health**	40	25	230
Age of Cow	8	7	230
Days carried calf**	32	18	230
Breeding/Reproduction problems	20	28	230
Other	10	18	230

* indicates the significance of a chi-square test for the difference between the variable and rbST use status
*** = significant at the 99% level; ** = significant at the 95% level; * = significant at the 90% level

e. Time of rbST Treatment, Response and Feed Monitoring

When rbST first burst onto the scene in the early 1980s, it was assumed that producers who adopted the new technology would have to inject their cows every day throughout mid- and late-lactation. Giving injections to cows every day became a large issue with many in the dairy industry, and, in response, Monsanto developed a 14-day injection so that cows would only have to be injected every two weeks. Since its commercial availability in 1994, it has also become clear that dairy producers use rbST in a number of different ways. While many producers do use rbST on selected cows throughout the entire mid- and late-lactation period (about 200 days), others use it selectively for periods of 40-50 days to 120-150 days for a variety of management purposes. In order to estimate the additional milk production in any year due to rbST, we needed much more accurate estimates of the time of treatment. Therefore we asked respondents to indicate when they started to treat cows with rbST and when they stopped using it. We asked respondents to provide their answers in terms of days in milk (DIM). However, many producers do not think about rbST treatment in terms of days in milk. Many producers decide to treat cows with rbST based on when they get pregnant, or the number of days carried calf (DCC). Since not all cows freshen in some convenient time like 60 or 90 DIM, and since some take as long as 120 – 150 days to get pregnant, the answers to questions about the start or finish of rbST treatment cannot always be interpreted neatly in terms of DIM. We received a variety of answers to the questions about the start and finish of rbST treatment, and so we have taken the liberty of "interpreting" the answers given and converting them into days in milk (DIM). We have tried to be consistent in interpreting the answers we converted, but the reader should be

warned that some of our interpretations may be rather liberal, and many of them just plain wrong. Nevertheless, our "interpretations and conversions" have allowed us to estimate the time of treatment of rbST. These are reported in Table 33.

We also asked regular and irregular users to indicate the percentage increase in milk production for the entire lactation due to rbST, and whether they monitored feed intake due to rbST treatment. Finally, respondents who classified themselves as "might use in the future" were asked what percentage response they would expect if they used rbST.

Table 33: Average DIM of starting and stopping rbST treatment, average time treated, actual and expected percentage response rate, and percentage of respondents who monitor feed intake due to rbST.

	Regular	Irregular	Might Use	Count
Start Treatment (DIM)	99	105	n/a	209
Stop Treatment (DIM)	282	279	n/a	203
Time Treated (DIM)	184	175	n/a	203
% Response (for entire lactation)	12.08	11.71	11.17	248
Monitor Feed Intake due to rbST	34%	35%	n/a	226

The average time of beginning treatment and ending treatment, and therefore the average total time treated, are remarkably similar in both groups. Regular users begin their treatments earlier and end their treatments later than irregular users, resulting in slightly longer average time of treatment for regular users. An ANOVA test for differences in the means confirms that there are no differences between the two groups. Table 34 reports on the essential differences between the two groups.

Table 34: Average DIM of starting and stopping rbST treatment and average time treated, by rbST use status.

	Count	Average	Std. Dev.	Min	Max	Median	Lower Q	Upper Q
Regular								
Start Treat	138	99	34	42	250	100	75	114
Stop Treat	135	282	15	203	340	290	280	290
Time Treat	135	184	34	40	270	190	170	200
Irregular								
Start Treat	71	105	39	10	200	100	80	120
Stop Treat	68	279	20	200	300	288	275	290
Time Treat	68	175	42	75	290	180	153	200
Total/Ave	203							

One of the most inconsistent statistics that has emerged over the many years of research and trials on rbST is the average response rate from use of rbST. When the first trials carried out by Dale Bauman at Cornell University were reported in the dairy science literature, many were struck by the single response rate of "up to 40%" increase in milk production. Most scientific studies and trials since that time report response rates in terms of volume of milk per day, or per treatment period. Numerous papers in the animal

science literature show that, with a few exceptions, use of rbST should increase milk production by 5 – 15 pounds per cow per day of usage. Recent trials over 6-injection cycles based on monthly test data showed an average increase of 10.97 lbs. per day, with a standard deviation of 2.89 lbs. and a range of 5.7 – 18.5 lbs. per day (Mike Overton, 2001).

[Add piece about our usage of 12% as an average response rate since 1985!]

While most producers continue to think of response rates from rbST in terms of increased volume of milk per day of treatment, we asked regular and irregular users to indicate the percentage increase in milk production over the entire lactation. We also asked the "might use" group what percentage increase in milk production they would expect to get if they used rbST. As reported in Table 35, the average percentages are surprisingly consistent, despite the fact that the ranges reported, especially the upper ranges, are somewhat extreme. An ANOVA F-test confirms that there is no significant difference between the means of the 3 groups.

Table 35: Average Percentage Response Rate (and Average Expected Response Rate) from rbST, by rbST use status.

	Count	Average	Std. Dev.	Min	Max	Median	Lower Q	Upper Q
Regular	134	12.08	5.38	5	47	10.5	10.0	13.0
Irregular	78	11.71	3.86	5	30	10.0	10.0	13.0
Might Use	36	11.17	4.50	1	21	11.5	8.5	15.0
Total/Ave	248	11.83	4.82	1	47	10.5	10.0	13.0

Finally, we asked regular and irregular users if they monitor feed intake due to rbST. This question was asked to try to separate out the effects of asking respondents if they monitor feed intake in general (see tables 8 and 24) from the effects of monitoring feed intake due to rbST use. As mentioned previously, if rbST usage is to be evaluated properly, producers really should monitor the increased feed intake for each individual cow treated with rbST. Otherwise it is impossible to properly evaluate whether the technology is cost effective. As reported in Table 34, only 34% of regular users and 35% of irregular users monitor feed intake due to rbST. These are surprisingly low percentages, and provide further evidence that many dairy producers evaluate the cost effectiveness of rbST based solely on the increased milk production they get.

Concerns about rbST

Despite the fact that about 45% of California dairy producers use, or have used rbST, since its commercial availability in 1994, a surprisingly high percentage of producers still have concerns about its use. Fully 97% of all respondents to the survey said they have concerns about rbST. Of course the type of concerns are different for each individual group. As indicated in Table 36, regular users are most concerned about cow burnout and public opinion about rbST use, followed by concerns about reproductive problems and whether or not rbST is cost effective. Adverse prices caused by excess supply of milk due to rbST use and injection of cows are lesser concerns, but nevertheless relatively important. All other groups have similar concerns, but in slightly different order. The industry as a whole ranks cow burnout, reproductive problems, public opinion, cost effectiveness and adverse prices due to excess milk supply due to rbST as their main

concerns. With the notable exception of the committed non-users, safety of rbST and injecting cows, together with insufficient research and "other" are relatively lower ranked concerns.

Overall, cow burnout, reproductive problems and public opinion could be considered to be the major issues associated with rbST use, by the dairy industry. A chi-square test for differences between the various groups shows that the largest significant differences occur with rbST safety (ranked high by committed non-users than other groups), cow burnout (ranked highest by irregular users, "might use" and committed non-users) and injection of cows.

Table 36: Concerns about rbST expressed by respondents, by rbST use status (Percentage of respondents)

	Percentage of respondents					
	Regular	Irregular	Might	Never	Total	Count
% with concerns*	94	100	98	98	97	522
Adverse prices**	28	33	17	39	33	510
rbST not safe***	4	11	4	25	15	510
Burnout***	44	75	52	71	63	510
Not cost effective*	34	46	46	33	37	509
Insufficient research**	5	12	13	17	13	510
Injection of cows***	25	29	28	24	26	510
Reproductive problems	39	50	54	60	52	510
Public Opinion	45	45	57	54	50	510
Other	16	17	9	21	18	508

* indicates the significance of a chi-square test for the difference between the variable and rbST use status
*** = significant at the 99% level; ** = significant at the 95% level; * = significant at the 90% level