What Type of Rancher Looks for New Technology

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Colleges of Agriculture have long championed the investigation and development of technology in agriculture. With the success of the hybrid corn research of the early 1930's, technology and biotechnology have played an important role in agricultural experiment station research programs. Colleges of Agriculture and their new partnerships throughout the university provide excellent avenues for formal technological training. What these formal departments do not provide is "technological literacy" (Drucker 1986). "Technological literacy" is an understanding of new technology and its dynamics, the opportunities it provides, and its impacts on product and process, markets, organization structures, and people. Agricultural producers, who are being constantly bombarded with new products, need technological literacy to effectively select and use these products.

In this paper, we discuss the adoption rate of a new product, *Trichomoniasis Foetus* vaccine, as well as the factors which influence its adoption. To accomplish this, the paper is divided into three parts. First, the seriousness of the trichomoniasis virus in western ranching operations is discussed. Second, we present an analysis of surveyed ranchers as to their likelihood to adopt *T. foetus* vaccine for their cattle. Finally, we present factors which influence the adoption of the vaccine by Nevada ranchers and discuss policies or programs that may influence the adoption rate.

Trichomoniasis and *Trichomoniasis foetus* vaccine

Trichomoniasis *(Trich)* is a disease of beef herds caused by the protozoan *Trichomoniasis foetus*. It is a venereal disease of cattle causing reproductive failure or abortion and thereby considerable economic loss in areas of the world where natural breeding is used (Rae 1989; BonDurant et al. 1990). This disease is one of the common infectious diseases causing decreased reproductive efficiency in Western United States' beef cattle operations (BonDurant 1985). Kvasnicka (1991) reported that *Trich* has been diagnosed in 46 % of Nevada cattle herds and that these herds are experiencing reproductive inefficiency. It has been estimated that approximately 80% of Nevada range herds have experienced reproduction problems. Some cows develop a natural immunity and conceive and carry a calf to term after three to five heat cycles following an abortion. However, the immunity is not permanent and the cow is subject to reinfection in subsequent breeding periods (Parson et al. 1976).

Producers and veterinarians have employed a variety of measures to control or eliminate *Trich* from infected herds. These include using young bulls, culling open cows after a short breeding season, not sharing bulls, buying only virgin breeding stock, and having fences in good repair to keep animals out. Although these recommendations have been somewhat successful, the increase in *Trich*, especially in the Western United States indicates these practices are not uniformly successful (BonDurant 1985). The failure of preventative measures may be attributable to lack of compliance in testing, reluctance to test when producers are experiencing drought and lack of nutritional resources, animal movements throughout the United States, lack of reliable and sensitive diagnostic tests and the practice of grazing beef herds in shared pastures (Speer and White 1991).

A *Trichomoniasis foetus (T. foetus)* vaccine was developed in a cooperative venture between Fort Dodge Laboratories and the University of Nevada. The USDA granted Fort Dodge a conditional license to market the vaccine in 1989. Research at the University of Nevada has demonstrated the efficiency of the vaccine and its impact on reproductive efficiency (Hall et al. 1991). In a later study by Kvasnicka et al. (1991) a control and vaccinated group of heifers were bred to *Trich* infected bulls. Of the vaccinated heifers 62.5% produced calves while only 31.5% of control heifers bore calves.

With the recent availability of *T. foetus* vaccine, factors which have or would influence its adoption or diffusion are of interest to extension educators, western livestock producers, and commercial business distributors. Agricultural producers may perceive obstacles to adoption of a new technology that are not apparent to outside observers (Lesser et al. 1986). Knowledge of the factors that lead to the use of *T. foetus* vaccine may assist us in developing educational and promotional programs that enhance its adoption rate.

Numerous studies have used statistical techniques to

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explain the adoption and diffusion of new technology. "Adoption" refers to individual decisions, while "diffusion" is the overall impact of all of these individual decisions (Lesser et al. 1986). Most analytical literature for both adoption and diffusion focuses on an after the fact explanation of the process. Griliches (1957) was the first to quantify technological diffusion in agriculture (hybrid corn) and methods were updated by Dixon (1980) using a variety of probability frameworks. Studies specifically addressing the Bovine somatotropin (BST) have attempted to predict adoption rates before a new technology is available; i.e. a before the fact process. Since *T. foetus* vaccine has been distributed for approximately four years, this study is an "after the fact" approach.

Survey Results

To estimate the factors which influence adoption rates of the vaccine by range cattle producers, a sample of 125 Nevada ranchers were drawn randomly from a list of 774 ranchers. The sample size is approximately sixteen percent of total (listed) population and eight percent of total state beef cattle operations from the 1987 Census of Agriculture (U.S. Department of Commerce, 1987). Our survey was conducted by Nevada Agricultural Statistical Service (NASS).

The sampled ranchers for the study were selected from a comprehensive list of Nevada beef operations maintained by the NASS. The list covers roughly seventy percent of the estimated total in the state. We tried to secure data from all the different sized operations as indexed by the number of cattle owned. A questionnaire was mailed to each member and the survey was completed by telephone. Out of one hundred twenty-five mailed, ninety-five questionnaires were completed for a response rate of seventy-six percent.

Some of the characteristics of the sampled ranchers are as follows. Average age of the respondents was 53.9 and average years of education was 13.2. Thirty-four percent of the respondents had some sort of specialized education, e.g., agribusiness, agricultural economics, animal science, animal husbandry, etc. Sixteen percent of the respondents used professional advice from paid consultants regarding their ranch management. Twenty-eight percent used a personal computer in their ranch operation and average duration of computer use was 5–11 years. Range of years of experience of ranchers in this survey was 31–75 years. Average land holding size, including deeded and allotment holdings of the respondent ranchers, was 92.8 thousand acres. Average herd size was 860 head. Ninety-four percent of the sample ranchers had been aware of the *Trich* virus for at least eight years. Forty-five percent of the respondents who were aware of *Trich* did not have their herd checked by a veterinarian. Seventy-two percent of the respondents were aware of at least one of the *Trich* vaccines. Almost forty percent of the respondents had already used *Trich* vaccines on their cattle. Seventy-eight percent of them indicated improvement in their herd condition.

Since the *T. foetus* vaccine has only been available for four years, the survey participants were divided into five categories:

(1) those who have used the vaccine; classified as *Users*,
(2) those who will probably use the vaccine but prefer to wait; classified as *Waiters*,
(3) those who will not use the vaccine in the future; classified as *Non-users*
(4) those who are unsure of their future actions regarding use of the vaccine; classified as *Do not know*, and
(5) those who are not aware of the vaccine availability; classified as *Have not heard*.

Twenty-five percent of the respondents indicated they had not heard of any vaccine. This was quite surprising given that the vaccine has been commercially available for the last four years. This also indicated that development of new technology does not mean it will be incorporated into all agricultural enterprises. Education and marketing of new technology was required for its use and proper application in agriculture. This would give credence to further development of extension and marketing programs for increased awareness of the *T. foetus* vaccine.

Approximately forty-two percent responded as current or future users of the vaccine, while twenty percent of the respondents belonged to the *Waiter* group. Seven percent were not sure they would use the vaccine in their ranching operation, and were classified as *Do not know*. Six percent, classified as *Non-users*, indicated that they would not use the vaccine. Respondents of the *Non-user* and *Do not know* categories justified their actions because their herd was free from *Trich*, their herd was closed or fenced, and/or they always used virgin bulls.

Special education and use of personal computers were found to be the two factors most highly related to acceptance of the vaccine. For the *User* category, 50% of the respondents used personal computers and 41% had some type of special agricultural education (Table 1). Of the specialized education, 79% had degrees either in agricultural economics or animal science. Average land holdings for the User group were the highest and the average age of a *User* respondent was the youngest for all the categories. Average herd size for *Users* was second to *Waiters* while on average, respondents in the User category have the least experience (29.8 years). Percentage of total earnings attributable to ranch operation was lowest for the *User* category when compared to others. For *Users*, sources of information pertaining to the *T. foetus* vaccine was found to be most important if it came from local veterinarians (68%) followed by state extension specialists (44%).

Waiters have, on average, smaller ranches both in terms of herd size and land size, but their dependence on ranch earnings as a proportion of their total budget was higher than the *User* category. However, an average member of the *Waiter* group was the most experienced and least educated of all five respondent categories. *Waiters* ranked next to *Users* in computer use, but were lowest in extended education. For the *Waiter* category, the veterinarian was the

Table 1. Characteristics of Respondents in Several Categories.

Variables	Units	Mean Values for User	Waiter	Non-User	Don't Know	Have Not Heard
Education	years	13.7	12.7	14.2	13.7	12.9
Herd Size	100	11.8	7.5	12.0	6.4	4.1
Experience	years	29.8	35.1	32.8	30.4	32.2
Land Size	1,000 acres	134.9	59.4	87.8	114.5	37.4
Age	years	52.2	53.6	53.4	53.9	55.7
Percentage of Total Revenue	%	90.4	93.3	96.0	100.0	78.4
Personal Computer	%	50.00	22.2	20.0	14.3	10.0
Special Education[1]	%	41.4	23.5	60.0	42.9	20.0

[1]Respondents with College of Agriculture majors were classified as special education.

most important source of information about the *T. foetus* vaccine. Sixty-one percent of *Waiters* obtained information from veterinarians while forty-five percent obtain information from state extension specialists.

Non-users had the highest years of education, and sixty percent had specialty education which was the highest of all five respondent categories. *Non-users* ranked third in both herd and land size. *Non-users* and *Waiters* on average had similar durations of experience in the industry, but only 20% of *Non-users* employed in their cattle operations.

For the *Non-user* category, veterinarians were the most important source of information. Eighty percent of *Non-users* obtained information from their veterinarian and only 20% indicated extension specialists were a source of information.

All of the respondents who were not sure about adopting the vaccine *(Do not know)* category, derived 100% of their total earnings from cattle operations. On average, members of the *Do not know* category had higher levels of education, but less than average experience. As to operation size, respondents in the *Do not know* category had the smallest herd size, but were second to the *User* group in average land size of operation. As to sources of information about the vaccine, respondents of the *Do not know category*, 71% said they received information from a veterinarian while 43% received information from a state extension specialist.

The last group of interest was *Have not heard.* They were the smallest in relation to land size and herd size, and ranked lowest in computer use and extended education. They had below average education and ranked lowest in their dependence on ranch revenues. Experience-wise, this category ranked third, however, the average age of these respondents was the highest.

All respondents were asked if they perceived any possible risk in the use of the vaccine. Only 4 respondents indicated there was no risk and the rest of the respondents indicated it was too early to make a judgment. The potential users were also asked how they would choose animals to inoculate and whether they would inoculate their herd randomly or follow a pattern. None of the respondents indicated that they would use random selection. The same respondents also indicated that they were not going to inoculate their entire herd. Of interest is that many of the respondents in the *Waiter* category said they would not inoculate their herds before their cattle became infected. It is beyond scope of this project to decide if waiting is a financially viable alternative to regular vaccination of the herd.

The fast adopters of *Trich* vaccine tended to be younger, better than average educated, used modern technology and operated with large herd and land size. Other potential adopters relied more on their ranch operations as their source of income and they tended to be more experienced. Those who have not heard of *Trich* vaccine tended to have less than average education, less extended education, very small herds, and were the least likely users of personal computers.

Factors Influencing Adoption of the *T. foetus* Vaccine

To analyze the adoption of the *T. foetus* vaccine by Nevada cattle ranchers, we used an analysis patterned after the works of McFadden (1974) and Domencich and McFadden (1975). We assumed that each rancher attempted to maximize his present value of profit through choices of different production technologies.

Our choice of independent variables was very crucial for explaining the dynamics of adoption of the *T. foetus* vaccine. The choice of variables was guided by two factors: human endowment and physical (production) endowment. The human endowment factors allow a potential user to

understand and decode information (Schultz 1964, 1975) and thereby help the diffusion of new technology. The second set of factors (physical endowments) affects the choice and/or desirability of a particular technology. Seven variables were included in the model to represent human capital. The variables are years of education, years of experience in ranching operations, a variable to represent whether the rancher uses a computer in the ranching operation, a variable depicting whether the rancher obtained information pertaining to the *T. foetus* vaccine from cooperative extension, a variable indicating whether other ranchers were sources of information and a variable indicating whether the rancher took advice from a paid consultant. To describe the production endowment influence on adoption, two physical variables were used to index the effect of farm size. These two variables were (1), the number of cattle, (the sum of bulls and cows) and (2), the total acreage of the operation.

To examine the dynamics of diffusion of the vaccine, five different adoption schemes were examined. Potential adopters were divided into two broad categories: those who had not heard of any vaccine for *Trich* and those who had. The first group was called *Have-not-heard*. The second group was subdivided into four more categories based on their responses regarding adoption of the *Trich* vaccine: *User, Waiter, Non-user* and *Do-not-know*.

The values predicted by our analysis closely tracked our actual observations. From Table 2, increase in herd size improved probability of both potential adoption groups (*User* and *Waiter*) up to a certain point and then declined. Herd size increase from 100 to 2,000 increased the probability of being an immediate *User*, but herd size over 2,000 reduced the probability. Similarly, the probability of being a *Waiter* decreased as the herd size increased beyond 1,000. An increase in experience from 15 years to 50 years increased the probability of *Waiter* by 8% and reduced the probability of *User* by 1%. Increase in land size, say from 1,000 to 100,000 acres had marginal effect on the probability of being an adopter. The increase is about 2% for both groups. Increase in education from high school level to college did not significantly alter the probability of being an adopter. However, it reduced the probability of *Have-not-heard*. As expected, an increase in the number of veterinary check-ups had significant impact on the increase in the probability of being an adopter. A rise in the number of veterinary check-ups from 0 to 3 increased the probability of immediate adoption by 18% and that of *Waiter* by 13%.

Next, we examined the difference in the probability of being in each adoption category with respect to each of the discrete variables. In this analysis, the variable in question is altered while the remaining variables are held at their mean levels. A rancher with a personal computer, had a 23% higher probability of being an immediate adopter. The probability of being a cautious adopter, *Waiter*, was reduced by 4%. Similarly, when extension was the source of information regarding the vaccine, the probability of immediate adoption increased by 23% and that of *Waiter* increased by 7%. If a rancher obtained information from other ranchers, the probability of being a *Waiter* increased almost four-fold. The effect of paid consultants on the probability of immediate adoption was marginal and reduced the probability of *Waiter*. Table 2, therefore, reveals that intensive cooperative extension programs, further computer orientation, inducement for more veterinary check-ups of herd, and finding an optimum herd-size could be important variables related to adoption rates of herd health technology.

Conclusions

Our analysis found a wide difference between five categories of respondents in their responses to possible adoption of a *T. foetus* vaccine in their ranching operations. As

Table 2. The probabilities of being in each adoption category based on different values for herd size, years of experience, years of education, veterinary check-ups, acreage in production, computer usage, attendance at extension programs, conversations with other ranchers, and use of consultant

Variables	Users	Non-users	Waiters	Do-not-know heard	Have-not-
			(%)		
Herd Size (head)					
100	36.0	1.5	15.9	18.8	28.1
500	41.9	3.3	24.3	4.9	25.6
2000	52.1	18.1	18.3	0.0	11.4
3000	47.2	37.1	11.0	0.0	4.7
Experience (years)					
15	47.3	3.8	20.7	1.2	26.9
30	46.6	5.2	24.1	1.2	22.9
50	46.5	7.6	28.9	1.2	17.8
Education (years)					
10	46.9	3.6	23.7	1.2	24.6
15	46.0	6.6	24.8	1.2	21.3
Vet Check-ups (number)					
0	36.3	8.6	17.7	1.2	36.3
1	44.7	5.6	23.5	1.2	25.0
3	54.6	4.0	30.7	0.7	10.0
5,000	45.0	7.6	22.6	1.2	23.6
10,000	45.1	7.5	22.7	1.2	23.6
100,000	46.6	5.2	24.7	1.2	22.3
Computer					
No	39.1	7.7	25.3	2.4	25.4
Yes	63.0	12.0	21.8	0.0	14.0
Extension					
No	40.0	6.6	22.5	1.2	29.8
Yes	62.7	2.9	29.3	1.2	4.0
Other Ranchers*					
No	53.9	5.1	15.7	0.0	25.2
Yes	22.9	7.0	59.0	3.6	7.5
Consultant					
No	45.6	50.5	27.1	0.0	22.3
Yes	47.0	10.1	5.8	15.6	21.6

*The Other Ranchers category indicates if a rancher obtained information about the *T. foetus* vaccine from other ranchers.

explained in terms of the respondents' human capital and production endowment, our estimates show that potential adoption of the vaccine by cattle ranchers in Nevada is about 62 percent (based on *Users* and *Waiters* categories). Our analysis also identified the factors and/or ranchers' characteristics that may affect adoption of the vaccine. Cooperative extension programs, use of computers, veterinary check-up of the herd, and herd size were found to be very important factors significantly increasing the probability of early adoption. Education did not appear to influence adoption rates, but it did reduce the probability of being a *Waiter*.

The probability of not using the vaccine lessened with increased herd size. The impact of a paid consultant and communication with other ranchers were also positive. Cooperative extension programs and veterinary check-ups reduced the probability of non-use. One important finding is the negative relationship between the probability of *Do-not-know* and *Have-not-heard* with herd size. Further analyses should be done to see why the smaller (in terms of herd size) cattle ranchers were undecided in their use of the vaccine and/or had no idea about the existence of such a vaccine four years after its commercial release. Veterinary check-ups and computer use reduced the probability of being in the *Do-not-know* and/or *Have-not-heard* categories. Extension information reduced the probability of *Have-not-heard* but failed to have any effect on the ranchers in *Do-not-know* category.

Further research is required to describe the financial impacts on a representative ranch from incorporation of the *T. foetus* vaccination in its operation. Also, alternative production practices, such as using only virgin bulls, fencing herds, etc. should be analyzed with respect to the *T. foetus* vaccination practices.

In closing, the adoption of technology such as *T. foetus* vaccine was increased by cooperative extension programs. Given present day biotechnological changes, the impacts of cooperative extension on the incorporation of biotechnology into actual production and more importantly the correct application of the technology in these agricultural systems is a major concern.

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