The use of a marketing approach to improve the development of new technologies: A case study

T.G. PARMINTER

AgResearch, Whatawhata Research Centre, Private Bag 3089, Hamilton, New Zealand.

ABSTRACT

To predict farmer adoption of new technology, distinctive approaches have been developed within a number of social research disciplines. Some of these have focused on the range of personal characteristics of farmers. In others, marketing techniques have been used to analyse production limitations and farmer objectives to understand technology adoption. Biological scientists in New Zealand have in general acknowledged a role for social scientists in describing the economic and social conditions surrounding farmer innovativeness, but have seldom allowed that to influence the development of new technology. The central proposition this paper is that a marketing approach to the development of farm technologies will improve their adoption rate.

A survey of farmers in New Zealand's Waitomo District has been previously reported in a study of their decisions to adopt beef breeding cow technologies (mating yearling heifers, using crossbred beef dairy cows, and terminal sires). In this paper ten attributes of the three technologies identified by farmers are reported as influencing their adoption or non-adoption decisions. When these attributes were included in logit regression equations, the equations were 70-74% correct in predicting which farmers had adopted technologies and which had not. It is concluded that new technologies will only be adopted if they meet farmer expectations when applied within farm production systems. To improve rates of adoption, researchers need a greater understanding of the attributes of new technologies that will be used by farmers to evaluate them. This can only be achieved by involving farmers at all stages of the developmental process.

Keywords: extension; agricultural marketing; adoption; breeding cow; beef cow.

INTRODUCTION

Early studies to explain and predict the level of adoption[1] of new technology[2] by a community examined the presence or absence of farmer innovativeness[3], as the significant contributor affecting technology uptake. Innovativeness of farmers was indicated by a combination of individual personality, their social characteristics, the strength of their perceived need, and the social system's norms (Rogers & Shoemaker 1971).

According to Gatignon and Robertson (1985) however the categorisation of people into levels of innovativeness has lacked consistent results in empirical studies, and cannot be applied across product categories or interest domains. Ashby (1982) considered that differing patterns of adoption reflect differences in agroclimatic conditions, not differing propensities to innovate.

The incorporation of agricultural and climatic, as well as social and economic factors in developing new technology has been an integral feature of participatory approaches to technology development. In these a whole system perspective is taken including the farmer, farmer's family, and rural community. Participation approaches include Rapid Rural Appraisal, Farm Systems Research, Farmer First, and Farmer Participatory Research. All include local farmers as members of the teams that describe and develop research opportunities in their area (Chambers *et al.*, 1989).

A number of researchers examining technology adoption have applied marketing theories relating the fit of new technologies to the perceived needs of consumers. This is particularly in the area of adoption of industrial products (Wilson & Ghingold, 1987). As a result, consideration has been made to the characteristics of new agricultural technology that affect adoption.

Rogers, Burdge, Korsching, and Donnermeyer (1988) have listed these as:

- the relative advantage of new technology, including its financial benefits
- the compatibility of new technology with the existing production system and the values and beliefs of the decision maker/s
- the apparent complexity of the technology in order to operate it successfully
- the ability of the technology to be trialed without an irreversible and large resource commitment
- the observability of the application and effectiveness of the technology

[1] Adoption being a decision to make full use of a new idea as the best course of action. Rejection is a decision not to adopt an innovation. Discontinuance is essentially adoption of an innovation followed by rejection (Rogers & Shoemaker 1971).

[2] Technology is usually taken to mean the set of physical processes, methods, techniques, tools and equipment used by farmers for agricultural production (Skinner 1982).

[3] "An innovation is an idea perceived as new by those who are confronted with it as an option of choice." (Solo & Rogers 1972). Innovativeness involves changing patterns of production or consumption to include new ideas (Gatignon & Robertson 1989).

O'Keefe and others (e.g. Gray *et al.*, 1992) proposed that agricultural technology like any other technology requires market research as part of its development. Marketing input into the development and extension of new technology utilising existing communication networks of farmers would have more effect upon adoption rate, he concluded, than the innate innovativeness of the consumers.

In this study, the relative importance of sociological, marketing, and economic factors were examined in relation to the adoption decisions of farmers. Factors were identified that will assist agricultural scientists wanting specifications for technology. Appropriate specifications should ensure that new technologies will be widely adopted by target groups.

The technologies studied were those that had been identified by the New Zealand Beef Council as being most instrumental in improving the financial situation of beef breeding cow farmers and the New Zealand beef industry (New Zealand Beef Council, 1989). The technologies had been researched and results published in scientific and farming journals between 1970 and 1990 (Carter 1973, Morris 1982, Morris & Baker 1987). They were:

1. Mating beef cows at 12-16 months of age (yearling mating) instead of at 24-28 months of age.
2. Using dairy-beef crossbred breeding cows rather than traditional beef breeds.
3. Using terminal sires of exotic beef breeds to produce progeny for meat production.

METHOD

The methodology is described in detail in a previous paper (Parminter, 1993), a summary is as follows.

One hundred and ten (110) beef breeding cow farmers in the Waitomo County were surveyed by personal interview. A semistructured survey design was used and additional material recorded on audiotape. The survey included questions on:

i. The farmer's current level of adoption of the three technologies.
ii. The farmer's background, education, and information sources.
iii. The farm's operational details and beef breeding system.
iv. The farm's business indicators.
v. The farmer's beef breeding cow beliefs, their beliefs about the technologies, and their learning experiences with them.

Farmers' beliefs about breeding cows and the three technologies were ellicited through open questions and categorised using the most generalised of the farmer concepts. A logit regression analysis (Hosmer and Lemeshow 1989) was carried out, identifying those variables associated with adoption of each of the three technologies. The logit function allows for the use of a dummy variable for its dependent variable. The dependent variables used in this analysis were the adoption (coded 1) or non-adoption (coded 0) of each of the 3 beef breeding technologies.

A standard logit function may be defined as:

$$\log [P_i/(1-P_i)] = B_0 + B_1X_{1i} + B_2X_{2i} + ... + B_kX_{ki} + e_i$$

where P_i is the probability that the ith individual will have undertaken a certain activity, X_{ki} are the independent variables, B_k are the coefficients to be estimated and e_i is the stochastic error term. Logit functions are based on the cumulative logistic function, which is an S shaped function.

The 102 independent variables available for the analysis were divided into 3 groups (a) farm and farmer attributes (b) farmers' core enterprise beliefs of the benefits of breeding cow enterprises and (c) farmers' beliefs about the 3 technologies. Forward and backward stepwise logistic regression analyses were conducted on these 3 groups of variables to ascertain the most influential variables affecting the adoption of the 3 technologies. The program Logit, a supplementary module for Systat (Steinberg & Colla, 1991) was used for the analysis. A significance level of 0.05 was used to either enter (forward) or remove (backward) variables from the model. Consistent results were achieved from either forward or backward regressions.

Once the most significant variables had been selected within each of the three groups by this process, groups were combined and a further logistic regression analysis was carried out, the results of which are reported in Table 1. In the next section the results of analysing groups (a) and (b) will be described as Factors Associated with Farmer Innovativeness and compared to the Technology Attributes of group (c).

RESULTS

Factors associated with farmer innovativeness

Of the demographic and production variables included in the survey, only those relating to farmer age, their beliefs about the value of their breeding cow enterprise, and whether or not they weighed their livestock, contributed to the final logistic regression equations. Many farmers surveyed associated the technologies being studied with increasing complexity of grazing management (especially around calving), this conflicted with their value of cows providing a feed match and feeding flexibility, as a result they were less likely to have adopted the technologies. The demographic and production variables are shown in Table 1 as farmer innovativeness variables. Also shown in Table 1 are the variables chosen when using only technology attributes in the logit regression analysis; and when selecting from both farmer innovativeness and technology attributes together (combined analysis). The predictive ability of each analysis is included in Table 1 and the regression equations for the combined analysis in Table 2.

Technology attributes

The farmers had 10 factors that they used to evaluate the three technologies. The proportion of farmers who identified the positive (nos. 1-10) and negative (nos. 11-20) aspects of these is shown in Table 3. These attributes were unrelated to the beliefs about the benefits of beef breeding cows ($r<0.30$) discussed previously. Predictions of farmer decision making found that the negative perceptions about technology attributes that were commonly associated with rejection of the techno–logies were more influential than the positive perceptions that were associated with adoption. The negative perceptions developed as a result of apparent conflict between the new technology and the existing beef cow production

TABLE 1: Variables used in logistic equations for predicting adoption.

Technology	Variable type	Variable selected	Predictive value (% of right predictions)
Mating yearling heifers	Farmer innovativeness	Enterprise belief 3 Weighing breeding stock Farmer age	60.09
	Technology attributes	Belief 11 Belief 18 Belief 8	73.9
	Combined analysis	Weighing breeding stock Farmer age Belief 8 Belief 11 Belief 18	78.3
Using dairy crossbred cows	Farmer innovativeness	Enterprise belief 3 Weighing finishing stock Farmer age	59.1
	Technology attributes	Belief 17 Belief 1 Belief 19 Belief 5	70.1
	Combined analysis	Belief 1 Belief 5 Belief 17 Belief 19	70.1
Using terminal sires	Farmer innovativeness	Enterprise belief 3 Weighing finishing stock	58.9
	Technology attributes	Belief 17 Belief 14 Belief 2 Belief 19 Belief 8	69.5
	Combined analysis	Weighing finishing stock Belief 17 Belief 19 Belief 14	69.2

Refer to Table 3 for "Beliefs 1-20".
Enterprise belief 3 is that "breeding cows should have a feed demand that matches feed supply" (Parminter 1993).

TABLE 2: Equations of factors associated with beef breeding cow technology adoption.

Technology	Equation	Predictive value (% of right predictions)
Mating yearling heifers	1.393 + 1.81 * Wtbdg - 1.361 * A>50 + 1.688 * yblf 8 - 2.833 * yblf 11 - 2.653 * yblf 18	78.3
Using dairy crossbred cows	- 0.691 + 1.706 * xblf 1 + 1.858 * xblf 5 - 1.77 * xblf 17 - 2.478 +* xblf 19	70.1
Using terminal sires	1.455 + 1.494 * Wtfng - 2.025 * tblf 17 - 1.697 * tblf 19 - 1.685 * tblf 14	69.2

A>50	farmer greater than 50 years of age
Wtbdg	refers to weighing of breeding livestock
Wtfng	refers to weighing of finishing livestock
yblf 1-20	refers to the farmer's beliefs about the yearling mating technology (Table 3)
xblf 1-20	refers to the farmer's beliefs about the dairy crossbreed cow technology (Table 3)
tblf 1-20	refers to the farmer's beliefs about the terminal sire technology (Table 3)

system. The ten technology attributes listed in table 3 may be further described as:

- Herd productivity which was affected by those technologies that were perceived by farmers to influence the number of calves being weaned. This could be the result of a change in annual herd pregnancy rate, or cow rearing affecting calf survival. Some technologies changed the number of calves born in a cow's lifetime or affected her reproductive life. Other technologies were associated with altered bull fertility also affecting cow pregnancy rate.
- Progeny performance was affected by those technologies perceived as influencing calf size, others calf growth rates.

TABLE 3: Attributes used by farmers to evaluate the three technologies.

Attribute no.	Technology beliefs	Average proportion (%) of farmers (a) Rejecting technologies	(b) Adopting technologies
1	Greater herd productivity	36	60
2	Increased calf growth	34	56
3	Increased genetic gain	5	15
4	Greater hardiness	3	8
5	Improved temperament	3	14
6	Easier feed management	2	4
7	Greater compatibility with existing farm operation	4	11
8	Greater profitability	21	51
9	Greater market demand for calves	17	28
10	Positive peer pressure	2	7
11	Reduced herd productivity	30	12
12	Smaller calves	8	2
13	Reduced genetic gain	5	2
14	Greater animal health problems	50	31
15	Greater behaviour problems	6	5
16	Increased feed requirements	52	33
17	Unsuitability with existing farm operation	51	18
18	Reduced profitability	19	4
19	Calves less suitable for market requirements	28	9
20	Negative peer pressure	9	0

- Hardiness and animal health attributes were listed by some farmers who considered that the technologies affected cows' susceptibility to health problems. Cows which had a different level of constitution were also likely to be culled at a different age.
- Behaviour and temperament were perceived as being affected when some technologies changed the temperament of animals, including how they reacted to herding by dogs, and handling by people.
- Feed management changes were perceived when technologies altered the seasonal feed requirements of animals.
- Compatibility was affected when farmers perceived that some technologies applied to a breeding cow herd, had large effects upon other farm enterprises. They may also have resulted in changed requirements for farm labour and/or capital. Some technologies changed farm pasture utilisation or the expected sustainability of its operations. Other technologies required different management skills than had previously been applied on the farm.
- Profitability was considered to be affected by farmers in a number of ways. It could be in terms of annual cash returns to the farm, returns on investment, length of time until payback, and financial exposure from the size of technology costs.
- Market demand was affected by how well the weaner calves were perceived to have performed as finishing animals. It was also dependent upon vendors being able to put a consistently even line of calves before potential buyers. Unusual and variable colours resulted in calves being more difficult to sell.
- Persuasion and information affects resulted from some farmers who were influenced by peer pressure from other farmers about the technologies. Others were affected by the opinions of their advisers.

DISCUSSION

A marketing approach based upon identifying the attributes of each technology that affect farmers' adoption decisions will assist scientists developing new technology. The critical technology attributes discriminating between farmers adopting or rejecting the technologies were not those beliefs most commonly held by farmers (i.e. associated with herd productivity and calf performance). The critical beliefs were the perceived profitability of the technologies (No. 8), how much they conflicted with the existing farm operation (No. 17), and how much the resultant progeny would be discriminated against in the market place (No. 19).

The farmer innovativeness variables (e.g. farmer age) associated with adoption of these technologies may be a result of the complexity of applying the technologies rather than the innovativeness of farmers directly. During the survey, farmers indicated that mating yearling heifers increased conflict between grazing management decisions across the whole of the farm around calving time. Some said that they lacked the ability to resolve these successfully. This situation particularly applied to yearling heifer mating where rejection of the technology was related to complexity of grazing management.

The use of terminal sires however, was associated with very little change in grazing management requirements. Its adoption was unrelated to age of the farmer, or any other variables associated with innovativeness (e.g. being cosmopolite).

The analysis of financial variables indicated no potential for developing an economic model to predict farmer innovativeness. However the use of an alternative technology such as stock weighing (in this case an indicator of management style) did have an association with the adoption of quite different technologies.

In the introduction, five characteristics of innovations affecting adoption were listed, (relative advantage, compatibility, complexity, trialling commitment, observability). Of these the most significant in this study was relative advantage. Relative advantage was identified in terms of increased enterprise profitability, and animal productivity (beliefs 1, 2, 3). Relative advantages for the whole farm was also needed as breeding cow policies are usually integrated with other enterprises (e.g. breeding sheep, finishing cattle, etc) (belief No. 7). Market demand (belief No. 9) required that the results of the technologies were observable. Calves from crossbred cows and terminal sires were both able to be identified at livestock sales, and this influenced the adoption of these technologies.

For the technologies being studied, use of variables associated with farmer innovativeness was able to predict farmer adoption or rejection behaviour for 50-60% of the farmers. Use of technology attributes predicted the behaviour of 70-80% of the farmers. This latter group also included those farmers predicted by innovativeness variables so no advantage would be gained by using both sets of equations simultaneously.

Future research will develop appropriate techniques for scientists to incorporate user requirements when developing new technologies. Such studies will initially focus upon newly developing beef breeding cow technologies.

CONCLUSIONS

Farmers' attitudes and beliefs about new technology will be based upon the attributes they perceive the technologies have. Favourable beliefs and attitudes are required before farmers will adopt new technology. Therefore an understanding of farmers' perceived attributes of technologies is needed before their adoption levels can be predicted. Technology development and extension programmes need to address the same attributes if existing adoption levels are to be improved.

The marginal benefits that farmers require from new technologies are not necessarily related to their beliefs about the benefits of the core-enterprise that will use the technologies. Farmers wanting increased profitability from new technologies may not necessarily have a belief that the core enterprise should itself be directly profitable.

In the same way a person with no interest in sport may still keep themselves fit by training regularly for health reasons. In this instance farmers' goals may not include "profitability", but to justify the costs of making a management change they require the adoption of new technology to have a measurable improvement in profitability.

However, the new technologies being produced should not be in conflict with farmer's beliefs about their core enterprise e.g. "breeding cows are easy care". Any conflict that occurs will increase the level of relative advantage required of new technology before it will be acceptable to that group of farmers. So although many of the surveyed farmers rejecting the technologies identified as many benefits from the technologies as those who had adopted them, they had additional reasons for not adopting them. These were mainly perceived conflicts with the existing farm operation and management practices.

Scientists concerned about adoption of new technology by farmers should carry out additional research into the decision determining attributes of each technology. Farm Systems Research methods that involve users in developmental research and include whole farm systems in their evaluation will avoid conflicts with existing farm operations and the resultant rejection of new technology.

ACKNOWLEDGEMENTS

This research was carried out with the financial assistance of the New Zealand Meat Research and Development Council and the New Zealand Pastoral Research Institute Ltd.

REFERENCES

Ashby, J. 1982. Technology and ecology: Implications for innovation research in peasant agriculture. *Rural Sociology* **47.**

Carter, A.H. 1973. Mating beef heifers as yearlings. *Ruakura Farmers' Conference.*

Chambers, R., Pacey, A. and Thrupp, L. 1989. Farmer First: Farmer Innovation and Agricultural Research (ed.) Intermediate Technology Publications, 1989.

Gatignon, H. and Robertson, T. 1985. A propositional inventory for new diffusion research. *Journal of Consumer Research,* **11.**

Gatignon, H. and Robertson, T. 1989. Technology diffusion: An empirical test of competitive effects. *Journal of Marketing* **53.**

Gray, R., Ryan, P. and Phillips, T. 1992. The overlapping principles of marketing, adult learning and extension. *Proceedings of the Dairy Horizons* - The challenge for extension, La Trobe University, November 1992.

Hosmer, D.W. and Lemeshow, S. 1989. Applied logistic regression, John Wiley and Sons Inc., New York.

Morris, C.A. 1982. More beef by using more productive cows and by yearling-heifer mating. *Ruakura Farmers' Conference.*

Morris, C.A. and Baker, R.L. 1987. Beef cattle breeds and crosses. *Ruakura Farmers' Conference.*

New Zealand Beef Council 1989. New Zealand Beef Council Proceedings 1989.

O'Keefe, M. 1990. Technology transfer: key issues and future trends. Australian Institute of Agricultural Science, National Conference on Agricultural Extension 1990, Canberra.

Parminter, T.G., Power, M.P.B. and Shaw, D.C. 1993. The effects on adoption of beef breeding cow technologies of selected farm business standards, farmer demographics and farmer beliefs. *Journal of New Zealand Society of Animal Production* **53.**

Rogers, E.M. and Shoemaker, F.F. 1971. Communication of innovations - A cross cultural approach, The Free Press, New York.

Rodgers, E.M., Burdge, R.J., Korsching, P.F. and Donnermeyer, J.F. 1988. Social change in rural society: An introduction to rural sociology, 3rd edition. Prentice Hall, New Jersey.

Skinner, W. 1982. Technology and the manager in readings in the management of innovation, ed: M.L. Tushman, W.L. Moore.

Solo, R.A. and Rogers, E.M. (eds) 1972. Inducing technical change for economic growth and development. Michigan State University Press.

Steinberg, D. and Colla, P. 1991. Logit: A supplementary module for Systat. Evanston, I.L.: Systat Inc., 1991.

Wilson, D. and Ghingold, M. 1987. Linking research and development to market needs. *Industrial Marketing Management* **16.**