Chapter VI

Factors Influencing Technological Adoption

The Ministry of Agriculture through its network of Research Centers and the Renewable Natural Resources Sectors in the respective district administration is the key player in developing, adapting, transferring and disseminating technologies to the rural communities. The Renewable Natural Resources Extension Support Project (funded by the Royal Government of Bhutan and the Commission of European Communities), which supports and advocates the new approach of participatory extension has considerably strengthened the extension system in Bhutan. The Wang Watershed Management Project, which is also jointly funded by the Royal Government of Bhutan and the Commission of European Communities, plays a vital role in supporting the Renewable Natural Resources Sectors of the study area. These two projects work in conjunction with the Ministry of Agriculture and are, thus, instrumental in affecting technological adaptations and changes in tune to the changing needs of the farming community.

This chapter will explore the factors influencing the adoption of technology with special focus on rice blast management technologies.

6.1 Attributes of technology adoption

The top down process of traditional extension dictated farmers to adopt technologies developed by scientists and promulgated by extension agencies. The failure to adopt new technologies was blamed on farmers' attitudes and their lack of knowledge. The barriers to adoption were attributed to conflicting information, risk, implementation costs, lack of flexibility, complexity and incompatibility along with social and perceptional issues affecting adoption (Vanclay and Lawrence, 1992).

Traditional extension is based on the model of innovation diffusion of American rural sociology in the 1960s and 1970s (Buttel *et al.*, 1990) and follows a linear process by which, scientific knowledge is applied in practice (Röling, 1996). Nowadays, it is considered that the innovation is better understood as the result of interaction among different actors with complementary contributions, a new paradigm to participatory process of technology development (Röling, 1996). Buck *et al.* (2001) suggest that the appropriateness of an innovation with the capacities and preferences of the potential adopters is an important condition for its diffusion. Yet as Kristjanson *et al.* (2002) point out, the manner in which, agricultural innovations are diffused, tested, adopted, and used are shaped by a complex set of social, economic, and environmental factors. Such factors and impacts are also felt at many different scales (plot, farm, community, watershed, region) and over varying time horizons. Thus, technology diffusion and adoption is a complex process that does not conform to the conventional paradigm of linear process of diffusion.

6.2 Source of information, attitude, knowledge and training on rice blast

The survey covered credible sources of information, attitude and knowledge relating to paddy production, with special focus on rice blast management technologies.

6.2.1 Source of information

The sources of information on rice production included extension agents, neighbors, Research Centers, National Plant Protection Center, field days and mass media (radio, extension publications such as folders, leaflets, pamphlets and manuals).

The outcome of the survey presented in Table 37 indicates that extension agents contributed 96.8 percent of the information relating to agriculture either through trainings, field days or individual farmer visits. Farmers of Paro seemed to share more information with their neighbors (42.9 percent) than the farmers of Thimphu (26.9 percent). The Renewable Natural Resources Research Center, Yusipang, through its on-farm varietal trials had contributed 20.3 percent and the National Plant Protection Center at Semtokha, too contributed about 10.1 percent of the information on rice blast, either on districts' request or onsite field monitoring during the critical paddy-cropping season. The coverage of mass media and field days was negligible. Moreover, extension materials on farm practices, pests and nutrient management in local language (*Dzongkha*) are limited. Even if it is made available, written mass media materials may not be a good source of information in the foreseeable future, as the literacy rate of sample farmers in the survey area is only about 11 percent. Therefore, focus of extension should be on the audio-visual methods of communication.

Table 37. Source of information on rice blast management technologies

Source of information	Paro (n=91)		Thimphu (n=57)		Both districts (n=158)	
	No. reporting	%	No. reporting	%	No. reporting	%
Neighbor	39	42.9	18	26.9	57	36.1
Extension	87	95.6	66	98.5	153	96.8
Research Centre	17	18.7	15	22.4	32	20.3
Plant Protection	11	12.1	5	7.5	16	10.1
Field days	2	2.2	1	1.5	3	1.9
Mass media	5	5.5	0	0.0	5	3.2

Source: Survey, 2002.

6.2.2 Farmers' attitude and knowledge on rice blast

A successful rice blast management cannot depend on technology alone. It should include all possible approaches toward control of rice blast, ranging from a single component control method such as chemical spraying to the combination of control mechanisms used in a systems approach, which require sound knowledge on disease and other socio-economic and environmental factors as well.

Though, the growers are aware of rice blast infecting their crops, they seldom have adequate knowledge on the complex nature of rice blast that warrant identification.

Majority of the farmers lack management skills in avoiding or managing the predisposing factors that favor rice blast development at various crop growth stages. Therefore, being aware of the technology (Table 38) and agreeing that adoption of technology help control rice blast (Table 39) does not necessarily reflect the farmers' knowledge on rice blast and their skills on implementing management strategies (Table 40).

The response to the sample households' awareness on the recommended technologies was not uniform as shown in Table 38.

The highest response on the resistant variety (93.7 percent), followed by the chemical spray (73.4 percent), seed treatment (58.2 percent), fertilizer management (36.7 percent), water management (32.3 percent), and straw and stubble management (32.3 percent) reflect the gap of knowledge or awareness of the available technologies among the farmers of sample households.

Table 38. Farmers aware of different technologies in percentage (n=158)

Technology	No. of respondents aware of technology	% of respondent aware of technology
Seed treatment	92	58.2
Chemical spray	116	73.4
Water management	51	32.3
Fertilizer management	58	36.7
Straw/stubble management	51	32.3
Resistant variety	143	93.7

Source: Survey, 2002.

Many farmers agree that following recommended practices such as seed treatment (88 percent), chemical spray with fungicides (70.7 percent) and growing resistant variety (98.6 percent) prevent the crop from blast fungus infection. However, there were many farmers responding to water management (60.8 percent), fertilizer management (41.4 percent) and stubble management (49 percent), who actually did not have any opinion on their performance indicating that farmers either lack knowledge or were not aware of these technologies.

Some farmers disagreed with the chemical management (11.2 percent) from the experience of the past impact. The disagreement with chemical spray was particularly reported from Mewang block, which on further investigation revealed that the blanket spray after heavy infestation by the blast fungus during the blast epidemic in 1995 was the main reason behind this attitude. In general, the extension in the study site had focused mostly on disseminating the resistant variety and chemical control measures to prevent crop from rice blast.

Table 39. Farmers' attitude towards the recommended blast management practices

Technology	No. aware of technology	Of those aware, % responding		
		Agree	No opinion	Disagree
Seed treatment	92	88.0	9.8	2.2
Chemical spray	116	70.7	18.1	11.2
Water management	51	25.5	60.8	13.7
Fertilizer management	58	58.6	41.4	0.0
Straw and stubble management	51	37.3	49.0	13.7
Resistant variety	143	98.6	1.4	0.0

Source: Survey, 2002.

The adoption of resistant variety (97.9 percent) can be attributed to the sample households' positive attitude, i.e., their agreement that following recommended practices prevent rice blast disease. About 50 percent and 47.6 percent of the farmers adopted fertilizer management and chemical spray, respectively because of their agreement that following these recommended practices helped prevent blast disease. The fertilizer management here meant not applying or reducing the use of synthetic nitrogenous fertilizers. The result of fertilizer management cannot be generalized for the study area as 16 households were from one block (Wangchang). There was none, who had agreed adopted straw and stubble management. Overall, it could be concluded that the adoption of recommended practices or technologies was related to the visible impact of the disease and the technology. The result seems to justify the statement made by Robinson and Napier (2002) on diffusion model that the potential adopters must be convinced that they will receive immediate benefits from adopting innovations or they will not be motivated to act.

Table 40. Farmers' adoption of recommended technologies

Technology	No. agreeing with technology	Of those agreeing, No. adopting	Of those agreeing, %. adopting
Seed treatment	81	18	22.2
Chemical spray	82	39	47.6
Water management	13	1	7.7
Fertilizer management	34	17	50.0
Straw and stubble management	19	0	0.0
Resistant variety	141	138	97.9

Source: Survey, 2002.

The knowledge of farmers on rice blast is presented on Table 41. Many farmers have knowledge on rice blast (83.5 percent), but only 53 percent of those having knowledge on rice blast could identify the blast disease. Since, many farmers were growing blast susceptible local varieties in Thimphu, the knowledge on blast was higher (94 percent) than their counterpart in Paro (75.8 percent). However, only about half of those having knowledge could identify blast disease. Moreover, farmers could identify the rice blast at the advanced stage only, especially the leaf blast and panicle blast. This is an implication that more effort is required to enhance the knowledge of farmers on rice blast to effectively implement the control or preventive measures against rice blast.

Table 41. Farmers' knowledge on rice blast disease

District	Knowledge on Blast					
	Yes		No		Of those having knowledge, can identify rice blast	
	No.	%	No.	%	No.	%
Paro (n=91)	69	75.8	22	24.2	37	53.6
Thimphu (n=67)	63	94.0	4	6.0	33	52.4
Total respondent (n=158)	132	83.5	26	16.5	70	53.0

Source: Survey, 2002.

6.2.3 Influence of training on rice blast

An attempt was made to draw the relationship between farmers' participation in training and the adoption of management technologies as the surrogate indicators of positive impact.

45 farmers attended the training, out of which, 44 farmers grew resistant variety. With respect to those farmers, who were growing local varieties and attended training (23 farmers), 82.6 percent adopted at least one of the components of management strategies and 17. 4 percent did not adopt any of the management practices. With regard to those 82 farmers, who grew local varieties and did not attend training on rice blast, 58.5 percent followed at least one of the recommended practices of reducing the fertilizer use, seed treatment and spraying of chemicals on standing crop upon the advise of extension agents. It is not obligatory for the farmers to undergo training to gain knowledge of new technologies, as extension on their individual farmer visit advise or disseminate any

technologies relevant to the farmer at that particular point of time based on the their field observation and conditions. 41.5 percent of the respondents did not follow any of the recommended practices.

Table 42. Farmers' participation in the training and adoption of technology on local varieties

Influence of extension	Growing local varieties	
	No. of respondent	% of respondent
Training and change	19	82.6
Training, no change	4	17.4
Total trained	**23**	
No training and change	48	58.5
No training, no change	34	41.5
Total without training	**82**	

Source: Survey, 2002.

The proportion of farmers adopting the various components of management strategies is shown in Table 43. The technologies followed on local varieties were dominated by chemical spray. Chemical spray was used on the standing crop, usually after the crop was infected by blast fungus. Only 5 farmers in Wangchang and one from Lamgong sprayed chemical before blast fungus infected the crop. The cultural management followed here was the non-use of nitrogenous chemical fertilizer by the farmers of Wangchang, and burning or removal of straw and stubble by the farmer in Lugyni geog.

Of the 23 farmers, who attended training, 39.1 percent adopted seed treatment, 78.3 percent sprayed chemical, 4.3 percent followed water management, 21.7 percent did not use or reduced the use of synthetic fertilizers and 4.3 percent followed straw and stubble management. Of the 82 farmers, who did not receive training, but grew local varieties, 50 percent sprayed chemicals on infested fields, 14.6 percent did not apply or reduced the quantity of chemical fertilizer, 13.4 percent treated seed, 2.4 percent followed water management, and 2.4 percent followed straw and stubble management. It can be deduced that the training had positive impact on the adoption of technologies, while a half of those, who followed the recommended technology without having undergone any training on rice blast could be attributed to the influence of individual farmer visit by the extension agents. Extension agents advice farmers to spray chemical fungicides, if the disease is observed in the fields. Moreover, farmers seek advice from the extension agents for seed treatment or in most cases extension agent practically do it for them. However, the activity having less extension agents' involvement has lower percentage of respondents adopting the technology such as water management, and straw and stubble management.

Table 43. Percentage of farmers adopting the components of technology

Technology	Farmers reporting			
	Trained (n=23)		Not trained (n=82)	
	No.	%	No.	%
Seed treatment	9	39.1	11	13.4
Spray	18	78.3	41	50.0
Water management	1	4.3	2	2.4
Fertilizer management	5	21.7	12	14.6
Straw/stubble management	1	4.3	2	2.4

Source: Survey, 2002.

6.3 Land holding

Sarap and Vashist (1994) and Robinson and Napier (2002) gave the positive relationship between size of land holding and adoption of improved technologies. They state that there exists a positive influence of farm size on adoption of technologies as large farmers generate more income that sequentially provides a better capital base and enhances risk-bearing ability. The same result was found out by this study, where the difference in average wetland land holding of the adopters (1.1 acre) and the non-adopters (0.7 acre) of technologies on local varieties was significant at 1 percent. However, the difference in average wetland land holding of farmers growing local varieties (1 acre) and resistant varieties (1.3 acres) were significant at 5 percent significance level only, since most farmers tend to grow both the varieties, but the proportion of area devoted to improved varieties are normally higher than the local varieties.

Table 44. Influence of wetland holding on technology adoption

Household	Wetland holding (acre)	
	Mean	Standard deviation
Growing local variety	1.0[a]	0.9
Growing resistant variety	1.3[a]	1.1
Technology adoption on local variety		
Non-adopters	0.7[b]	0.6
Adopters	1.1[b]	0.9

Source: Survey, 2002.

Note: a and b indicate the significant difference at 5 and 1 percent level, respectively.

6.4 Farmers' perception of the quality of control

Bellon (2001) states that it is fundamental to identify the technological options and understand perceptions about the advantages and disadvantages of each one of them to assess the appropriateness of new technology or practices that suit farmers' needs better. The author further states that knowing how to elicit these perceptions, translate them into criteria for evaluating a technology, and use them to rank alternative technologies is important for working with farmers to develop and assess agricultural technologies.

Since, the effectiveness of technology strongly featured in farmers' decision criteria, ranking on the mean value of farmers' perceptions on the quality of control of recommended technology was carried out based on the method used by Bajgain (1993).

When viewed from Table 45, there is no denying that farmers highly regarded the excellent control of the improved variety to rice blast. The mean value for each item was based on the quality of control given by farmers as poor, fair, good and excellent and was assigned the corresponding values of 1, 2, 3, and 4, respectively. Then, the ranks were assigned to the mean value of the technology.

All the respondents in Thimphu reported excellent quality of control (mean value at 4) by the resistant variety (Chumroo), while in Paro, where farmers were growing more than one improved variety that had resistance to rice blast, reported the quality of control at the mean value of 3.9. Some farmers reported that though the blast symptoms were observed on some improved varieties, the yield reduction was not significant.

The mean values for chemical spray (2.9) and seed treatment (2.7) signify the mixed response due to many attributes influencing their efficacy such as skills, knowledge, timing, crop growth stage and severity of disease. However, there were visible positive impacts from the use of chemicals with the exception of few, who had bad experience during the 1995 blast epidemic blanket spray campaign.

Low mean value for cultural management (water, fertilizer, and straw and stubble management) indicates that farmers were not very positive about these measures. Farmers were not fully aware of the benefits from water management and farmers would not burn straw and stubble because of their multiple utility (feed/ fodder and beddings for cattle). They could not relate the blast disease occurrence with these management strategies.

The mean value from Table 45 also indicates that the farmers' view on the quality of control also affected their adoption, assuming that other factors did not constrain the adoption of technology. In general terms, more complex the innovation, the greater is the resistance to adoption. Complexity makes the innovation more difficult to understand, and generally requires greater management skills (Vanclay and Lawrence, 1992).

Table 45. Farmers' perceptions on the quality of control of blast management technologies

Technology	Paro			Thimphu			Total			Rank
	n	Total value	Mean value	n	Total value	Mean value	n	Total value	Mean value	
Seed treatment	12	31	2.6	8	23	2.9	20	54	2.7	3
Chemical spray	30	81	2.7	29	91	3.1	59	172	2.9	2
Cultural management	19	38	2.0	3	6	2.0	22	44	2.0	4
Resistant variety	90	350	3.9	48	192	4.0	138	542	3.9	1

Source: Survey, 2002.
n: number of respondents.

6.5 Patterns of Adoption

The traditional model of innovation diffusion, which follows the social-psychological notion of individual decision making with complex pattern of mental processes and activities occurring as a set of stages: awareness, information, evaluation, trial and adoption (Vanclay and Lawrence, 1992), theoretically leads to classifying farmers as innovator, early adopters, early majority, majority, late majority and laggards (Rogers, 1983). However, they are apt to state that adoption process is varied, complicated and does not always follow the theoretical stages from awareness through knowledge, trial and adoption.

Effective rice blast management demand the whole package of management strategies (especially cultural and chemical management for local varieties) to be adopted, which when followed in part may not be effective against blast fungus, in case of favorable weather conditions. On the contrary, it is found that the farmers compare their practices with alternatives and are more likely to adopt individual elements, rather than a complete technological package (International Maize and Wheat Improvement Center (CIMMYT), 1988). Consequently, farmers are cautious about committing themselves to complete adoption of management practices that they have not followed in stages (Vanclay and Lawrence, 1992) and so the index of acceptability of technologies is not uniformly distributed amongst the technological options.

6.5.1 Index of acceptability

Index of acceptability is one of the tools to assess adoption that reveals the extent of adoption of recommended practices and quantifies the adoption (Hildebrand and Poey 1995, cited in Norman *et al.*, 1995). The interpretation suggested by Hildebrand and Poey are as follows: if index of acceptability (I_a) exceeds 25 and 'C' (percent of farmers who are aware of the technology and using the technology on at least part of the crop at the time of interview) is equal to or greater than 50, it has a good chance of being adopted. Low 'C' indicates few farmers are adopting the technology; and low 'C' combined with a high 'A' (the percentage of the area planted with the new technology compared to the total area planted to that particular crop) indicates the use of technology on a large proportion of land planted to that crop.

The index of acceptability in the study area for seed treatment, water management, fertilizer management, and stubble and stubble management was very low at 8.6, 3.1, and 13.6 and 1.3, respectively. As the rule of thumb, these technologies had the least chance of adoption or in other words, the sample farmers least adopted them, especially the straw and stubble management, where farmers highly valued straw as feed for cattle and source of manure. The index of acceptability of chemical spray at 29.2 percent indicated that it had a good chance of acceptance by the farmers. In the real situation, farmers spray chemicals only after their crops are infested by the disease or upon visual evidence of the disease. Among all, the resistant variety had been widely adopted and accepted (68.4 percent) by the sample households.

Table 46. Summary of the index of acceptability of technologies

Technology	Respondents			Area (acre)	
	No. aware	No. adopted	C	A	I_a
Seed treatment	92	20	21.7	39.6	8.6
Chemical spray	116	59	50.9	57.4	29.2
Water management	51	3	5.9	51.9	3.1
Fertilizer management	58	17	29.3	46.2	13.6
Straw/stubble management	51	3	5.9	22.0	1.3
Resistant variety	143	138	96.5	70.8	68.4

Source: Survey, 2002.

Note: C = (No. adopted/ No. aware)*100

= Percent of farmers who are aware of the technology and using the technology on at least part of the crop at the time of interview

A = (Area with tech/ total area)*100

= Percentage of the area planted with the new technology compared to the total area planted to that particular crop

$I_a = (C * A)/100$

Further, the values of 'C' and 'A' were used to gain more insight of the magnitude of technology adoption. The value of 'C' for seed treatment (21.7 percent), water management (5.9 percent), fertilizer management (29.3 percent), and straw stubble management (5.9 percent) demonstrated that few farmers were actually adopting these technologies; and about half the sample households (50.9 percent) used chemical spray. The higher percent for 'A' compared to 'C' indicated the nature of technology, which had to be used for the whole area planted to paddy crop. Almost all the blast management technologies recommended to farmers had higher 'A' indicating that these technologies were required to be adopted for the whole field, except for straw and stubble management, where farmers were advised to remove or burn only those affected by the disease.

Both the values of 'C' and 'A' were very high for resistant variety, indicating wider acceptability over large area; however, the value of 'A' was lower than 'C' indicating that some areas were devoted to other varieties.

6.6 Farmers' choice and decision criteria of technology adoption

The decision criteria on various blast management technologies was based on the response to the questionnaire pretested with 30 farmers. The technological attributes of the resistant varieties were not covered, since they were exhaustively tested on farmers' fields before being promoted (Renewable Natural Resources Research Center-Yusipang, 1997, 1999, 2000). The criteria selected for technology adoptions were affordability (price of fungicides, fertilizers and seeds; labor cost for water, and straw and stubble management), effectiveness (quality of control), knowledge (having the basic understanding of rice blast in relation to its control by following the technology), and availability of inputs (fungicides, fertilizers, seeds, water and supplementary feed/fodder for straw). The respondents' decision to adopt rice blast management technologies depended on the type of technology that fulfilled their criteria of adoption. Hence, adoption criteria for a particular technology varied from one another as indicated by Table 47.

The adoption of seed treatment was determined equally by affordability of chemicals (55 percent) and effectiveness (55 percent) in controlling rice blast, followed by the availability of chemicals (45 percent) and the knowledge (25 percent) that treating seeds with chemical fungicides prevent the crop from rice blast.

Effectiveness of the chemical spray that displayed visual impact was the major factor contributing to its adoption. 78 percent of the respondents testified that they followed chemical spray because it was effective in controlling disease after spraying. Availability (37 percent) and affordability (20 percent) of chemical, and knowledge (13.6 percent) that spraying was necessary, were some of the factors that farmers based their decision to adopt chemical spray either before or after the crop was infected by the blast fungus. Farmers were not much concerned about affordability of chemicals because chemical fungicide was highly subsidized, while the extension agents helped them monitor their field from rice and also help them in preparing chemical spray.

Affordability (100 percent) of water management and availability of water (100 percent) and the respondents' knowledge (66.7 percent) that keeping paddy fields flooded with water was effective (33.3 percent) influenced farmers to adopt water management. If the water is available, then irrigation of paddy fields requires only a person either early in the morning or late in the evening before or after the normal working hours.

The adoption of fertilizer management was largely influenced by the affordability (100 percent) and availability (100 percent) of fertilizer, which was further complemented by the knowledge (58.8 percent) that reducing the amount of nitrogenous fertilizer than their normal practice or not applying nitrogenous fertilizer to the susceptible local varieties, avoid rice blast. 47.1 percent of the respondents reported that this recommendation was effective in reducing or lowering the incidence of blast in their paddy fields compared with their earlier or normal practice without following extension recommendation. Since, less amount of fertilizers were required than their normal practice (lower cost) and the chain of Commission Agents selling fertilizers, facilitating easy access, strongly influenced farmers' decision criteria to adopt fertilizer management.

The respondents reported that their decision criteria to adopt straw and stubble management was based on affordability of labor (100 percent), effectiveness in suppressing rice blast (100 percent), their knowledge that removing or burning straw or stubble would remove rice blast (100 percent) and availability of alternate fodder for their cattle (33.3 percent).

Table 47 shows that the affordability of seeds (100 percent) and effectiveness of resistant variety in controlling rice blast (82.6 percent) were the main decision criteria motivating farmers to adopt it. About 37 percent of the respondents stated of having adopted resistant variety due to its availability and the knowledge (92 percent) influencing its adoption. The affordability of seed was due to the fact that, majority of the farmers kept their own seeds that was initially supplied free by the District Agriculture Office on promotional program or by Research Centers through on-farm trials, they did not have to procure seeds in the ensuing seasons.

Table 47. Criteria used for determining the adoption of blast management technologies

Technology	Farmers	Criteria of adoption			
	adopting	Affordability	Effectiveness	Availability	Knowledge
	No.	--------------% reporting--------------			
Seed treatment	20	55.0	55.0	45.0	25.0
Chemical spray	59	20.3	78.0	37.3	13.6
Water management	3	100.0	33.3	100.0	66.7
Fertilizer management	17	100.0	47.1	100.0	58.8
Straw/stubble management	3	100.0	100.0	33.3	100.0
Resistant variety	138	100.0	82.6	37.0	92.0

Source: Survey, 2002.

The factors influencing technology adoption with regard to rice blast indicated in Table 47 are summed up as follows:

The technology intended for the farming communities should be inexpensive and simple in implementing the technology to control rice blast. Thus, the affordability of the components associated with adoption of technology is the most important factor that the farmers' based their decision whether to adopt or not to adopt technology (example: water, fertilizer, straw and stubble management). The technology adopted should be effective in controlling the disease or it should bring about noticeable changes (example: seed treatment; chemical spraying; straw and stubble management; and resistant variety). However, it is important to ensure the availability of inputs or access to complementary components required in adopting that technology (example: water, fertilizer and chemicals). The relatively simple techniques of technology and the farmers' knowledge on recommended technology that adopting it prevents from rice blast favored adoption of technology (example: straw and stubble management; resistant variety; fertilizer and water management).