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# GENERATION, ADOPTION AND IMPACT OF DIFFUSED LIGHT POTATO STORAGE TECHNOLOGY IN BADULLA DISTRICT, SRI LANKA

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# GENERATION, ADOPTION AND IMPACT OF DIFFUSED LIGHT POTATO STORAGE TECHNOLOGY IN BADULLA DISTRICT, SRI LANKA

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## BIOGRAPHICAL SKETCH

The author was born in Badulla, Sri Lanka on April 24, 1946, the youngest of ten children of Mr. S. M. Punchirala and Mrs. N. M. Dingirimenike. He had his primary educatton at Ginigathgala Vidyalaya, Haldummulla. He was granted a 5th grade scholarship to government Central College, Welimada and finished his secondary education in 1963. He entered the School of Agriculture, Peradeniya, Sri Lanka in 1963 and obtained a Diploma in Agriculture.

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He is happily married to Yamuna.

S. M. SOMARATNE

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# ABSTRACT

S. M. SOMARATNE, University of the Philippines at Los Banos November 1985. Generation, Adoption and Impact of Diffused Light Potato Storage Technology in Badulla District, Sri Lanka.

Major Professor: Prof. Vicente A. Martinez

The diffused light potato storage technology was introduced in Sri Lanka in 1979 to alleviate some of the problems encountered in traditional potato storage methods. This study aimed to investigate the processes involved in the development, adoption and diffusion of diffused light potato storage technology and its agro-socioeconomic impact in potato production system.

The data were gathered using interview schedules, informal interviews, records and ethnological observations involving 178 respondents. The data were analyzed to obtain frequencies, averages, percentages and ranks. The chi-square test was used to test the correlations, while logit model was used to predict the adoption probabilities.

The profile of farmer adopters revealed that they had average family size of 5.3, 43.3 years of age, 6.5 years of schooling, 16.8 years of experience in potato cultivation and 1.4 ha landholding.

Farmers encountered several storage problems in traditional potato seed storage methods causing more than 27 percent of storage losses. More than 51 percent of the total cost of production of potatoes was attributed to seed materials. Three distinctive adoption processes were identified: formal adoption process, iterative adoption process, and galloping adoption process. Predominant factors that motivated farmers to adopt DLS were its convenience, low cost, quality seed production and adaptability to their existing system. However, during the adoption process, farmers modified and adopted the DLS based on their evaluation and specific needs. More than 60 percent of the farmer adopters were satisfied with the present DLS storage and sustained the technology with them. Reasons given by farmers and extension agents for non-adoption of DLS were lack of security, funds and adequate knowledge.

More than 900 farmers adopted the diffused light potato storage technology in Badulla district since 1978 and the technology disseminated among the farmers in three different diffusion processes, namely: horizontal selective diffusion, core to periphery diffusion and ad-hoc diffusion.

Analysis of interaction among and between farmers, extension and research personnel showed that there was a minimal interaction between research personnel and farmers during the above processes but there was a formal off-farm interaction between other disciplines.

The agro-socioeconomic impact of diffused light potato storage revealed that there was a substantial increase in yield, income, social participation and reduced seed storage losses, drudgery involved in seed handling and time and labor used in seed storage practices.

# CHAPTER I

## INTRODUCTION

Sri Lanka grows up to 6500 hectares of potatoes (Solanum tuberosum) which produce 65000 metric tons annually for consumption (CIP, 1981). One of the major constraints involved in production is non-availability of good quality seed potatoes in adequate quantity for planting. During the past two decades demand on seed potatoes has increased tremendously due to the recognition of potatoes as a highly profitable crop when compared to other vegetable crops. It motivated farmers to increase the area under cultivation and the cropping sequence. Another contributory factor to the seed demand is the identification of new areas for cultivation apart from traditional areas such as Nuwara Eliya, Badulla, and Jaffna districts.

Until the later part of the sixties, the total requirement of seed potatoes had been imported from West European countries, involving considerable amount of foreign exchange. After that time there was increased demand for seed potatoes but the escalating price of imported seed potato prevented the importation of such a large quantity. Therefore, importation of seed potatoes was made for the Maha season (October-February) planting only. Exploring therefore, the possibility of producing local seed potatoes in higher elevations of above 1500 m as in Nuwara Eliya district where conducive environment prevails during most of the months of the year was made and it was found that good quality seed potatoes could be produced in this area. But the limiting factor in seed production beyond 1000 tons annually is the non-availability of suitable arable lands (CIP, 1981).

Rapid expansion of potato crop in medium-low elevation such as the South Central Badulla district where potato crop is grown on highland slopes under rainfed condition during the Maha season (October-February) and the Yala crop (June-October) grown in low land paddy lands aggravated considerably the seed demand. Farmers in Badulla district obtained their seed requirements for Maha cultivation from government farms through co-operatives which were either imported or produced locally. Some farmers obtained their seed requirements from farmers in high elevation presumably at a higher price than the government price. Farmers always prefer to buy sprouted seed potato at a relatively higher price than the freshly harvested potatoes from higher elevations which they could obtain at low price at the time of harvesting because they lack proper storage facilities which would enable them to store fresh tubers for 4-5 months after sprouting. The Maha crop is considered as seed crop and the major portion of the harvest in February and March will be kept for 4-5 months under traditional storage method until the Yala planting. The bulk of the yala harvest coincides with monsoonal rains and farmers are compelled

to harvest immature potatoes and send them to the market immediately after harvest. They are unable to keep some of the produce as seeds under this condition. Thus, they have to look for external sources of seeds for Maha planting.

Traditional storage methods not only cause storage losses but also reduce the quality of seeds. These methods seem not suitable for storing seed potatoes more than 4-5 months. To enable them to use their own seed potatoes at a low cost they need to store their produce for more than 8 months from the Maha seed crop to the next Maha planting.

Approximately 3000 metric tons of seed potatoes are being imported annually into the country costing 1.5 millions US dollars. Socio-economic conditions of the potato farmers in Sri Lanka limit the use of capital intensive storage methods. As small farmers, their need was a simple low-cost on-farm storage for a ton or so of potatoes that could minimize the storage losses and facilitate prolonged storage without deterioration in seed quality within economical limits.

With this in view the concept of diffused light storage (DLS) was introduced to Sri Lanka in late 1979's in collaboration with the International Potato Center (CIP,1983). Diffused light potato storage (DLS) refers to a seed potato storage method in which indirect light is provided on the stored seeds to prevent long etiolated weak sprout growths and to induce short sturdy sprouts on the tubers. This method ensures good seed quality and prolonged storage under natural ventilation and ambient temperatures. Initially after observations were made at government farms, the method was tested for its suitability and adaptability to the local setting. The first effort to expose farmers to the new DLS technology was made in 1980 when a few DLS demonstrations were established at strategic sites in Badulla and Nuwara Eliya districts. Extension programmes were carried out in both districts in order to disseminate the new technology to the farmers. It has been found that farmers' response to the new technology was encouraging and as a consequence many farmers in Badulla and Nuwara Eliya districts accepted and adopted it in place of their traditional potato storage method while other farmers modified their existing storage to some extent. By late 1984 more than 900 farmers adopted the new technology.

However, the potential for the expansion of this type of DLS to other areas is still to be desired and assessed. There are more than 15,000 small potato farmers in Badulla district and the use of the new technology would be practical and beneficial. An attempt to evaluate the impact of the new technology on potato production and on the farmers in these two districts is also necessary.

## Statement of the Problem

One of the major constraints facing the potato farmers in Badulla district is non-availability of good quality seeds at an affordable price especially at the time when they need it. Potato seed costs account for more than 50% of the total production cost (Van Der Zaag and Horton, 1982). Thus, farmers in these two districts have started to keep substantial amount of potato seeds for their subsequent plantings.

Conventional seed potato storage methods used by potato farmers in Badulla district had been found to cause not only considerable storage losses but also reduced the quality of seeds (Albert, 1980; CIP, 1984).

Normally, seed potatoes have to be stored for about 4-9 months after harvest in February-March if they have to be used for the next planting seasons. But seeds do not keep that long since sprouts appear even just after 3-4 months of storage. If seed tubers are kept longer after natural dormancy under conventional storage methods it will cause high storage losses due to pests and diseases and excessive production of etiolated weak sprouts (Potts, 1983). Potato seed tubers in such conditions are no longer good for planting.

It has been demonstrated that seed potatoes stored in diffused light under conditions of adequate ventilation in simple low cost structures have many advantages over conventional simple storage methods used by potato farmers (Booth, et al. 1982).

Diffused light storage technology has been developed elsewhere with interdisciplinary research efforts, with a view of bringing about an appropriate seed potato storage technology that can be put into practice under farmers' present agro-socio-economic conditions prevailing in the tropical areas. This study was conducted to find out the answers to the following questions:

How was the DLS technology disseminated to potato farmers in Badulla district?

How is the DLS technology being adopted by potato farmers?

What interaction processes took place between and among farmers, researchers and extension system in the development, adoption and diffusion of DLS technology?

What are some of the important impacts of DLS technology on potato production system?

## Objectives of the Study

Based on the problems above, the following objectives were developed for this study:

1. To determine the processes involved in the development, adoption and diffusion of DLS technology;

2. To analyze the interaction between and among the farmers, researchers and extension agents in the development, diffusion and adoption of DLS technology; and

3. To find out the impact of DLS technology on the potato production system in terms of agro-socio-economic aspects.

## Importance of the Study

Potato crop is grown in countries where wide range of ecological and socio-economic diversities is found. Substantial number of attempts had been made to transfer new technologies to small farmers in developing countries without much success partly due to the recommended technologies which often do not solve their agro-socio-economic problems and some of the solutions were not socially and economically acceptable to them. Thus the socio-economic aspect of farmers seemed to be a key factor in the adoption of new technologies.

Although a few similar studies had been conducted on agro-socio-economic aspects of adoption of the DLS technology under different setting in other countries (Potts, et al., 1983), so far no attempt has been made to look into the aspect of generation and transfer of DLS technology to the farmers as an interactive process in wider perspective, ever since its introduction in 1979 in Sri Lanka.

Hence a study of this nature is timely, because the technology was introduced several years ago and there is reasonably enough time period to identify the emerging implications as consequences of the new technology transfer and to evaluate its impact on farmers.

It is also relevant because it deals with potato seed storage which is one of the most important problematic areas where information is lacking in Sri Lanka.

Information from this study may also be used as preliminary data for researchers, extensionists, social scientists and others involved in development and/or disseminating future storage technologies for small farmers with more appropriate and acceptable form.

Lastly, the findings of the study may be used in future researches in an effort to understand the seed potato problems in Sri Lanka.

## Definition of Terms

Process of technology development - refers to the sequential activities that took place from problem identification stage, research stage for potential solution, testing and adaptation stage and final evaluation by farmers.

Process of diffusion - refers to the sequentially arranged series of steps in spreading the diffused light potato storage technology from the source of origin to the end-users.

Process of adoption - refers to the activities that took place sequentially from farmers' awareness of diffused light potato storage technology to final adoption of DLS and utilization by them.

Sustained adoption - refers to the farmers' acceptance and continuous utilization of DLS for storing seed potato after initial adoption.

Interaction - refers to the communication behavior, frequency of contacts and content of communication between and among farmers, extension agents and research personnel in the development, diffusion and adoption of DLS.

Impact - refers to both anticipated and unanticipated changes that occurred in the farmers' croping system, social system and economic system as a result of adoption of DLS technology. Severity index - refers to an index that indicates the severity of storage problems. Each storage problem was assessed by farmers according to their severity rank. Highest rank was given a score of 12 and subsequent ranks were assigned in descending order until last rank gets a score of one. Weighted average was calculated by multiplying frequency by the score for the rank and sum of the scores was divided by the number of ranks.

$$\text{Weigthed Average Score (WAS)} = \frac{f \times WS}{n}$$

where:

WAS = Weighted Average Score
f = frequency for a particular rank
WS = Weighted score
n = number of ranks

Weighted Average Score was divided by the total number of respondents to calculate the severity index.

$$\text{Severity Index SI} = \frac{WAS}{N}$$

where:

N = number of respondent

| Level of severity | Severity Index Range |
|---|---|
| 1. High | 1 - 0.66 |
| 2. Moderate | 0.65 - 0.33 |
| 3. Low | 0.32 - 0 |

Advantage index - To determine the technical, economical and social advantages perceived by the respondents, advantage indexes were developed using the following procedure:

Each advantage was given a score scale from 6-1, 5-1 and 6-1 in descending order of rank of technical, economical, and social advantages, respectively. Each score was multiplied by the respective frequency count and divided by the number of ranks. Sum of the scores was divided by the total number of respondents to get the mean advantage index for the particular advantage.

$$\text{Weighted Average Score (WAS)} = \frac{f \times WS}{n}$$

where:

f = frequency
WS = weighted score
n = number of ranks

$$\text{Advantage index (AI)} = \frac{WAS}{N}$$

where:

N = Number of respondents

| Advantage level | Advantage Index Range |
|---|---|
| 1. High | 1 - 0.67 |
| 2. Medium | 0.66 - 0.33 |
| 3. Low | 0.32 - 0 |

Effectiveness and usefulness of extension activities - To determine the effectiveness and usefulness of extension activities, a four-point usefulness scale was used as follows:

| | Score |
|---|---|
| Very useful and effective | 4 |
| Useful and effective | 3 |
| Fairly useful | 2 |
| Not useful and effective | 1 |

Total score for each extension activity divided by the frequency represents the mean usefulness and effectiveness score of a particular extension activity.

Level of social participation - Social participation is defined as any participation in agricultural extension activity and joining agricultural organization within the community. It was recorded by two indexes: number of agricultural extension programs, respondents' participation and number of agricultural organizations in which they affiliated and participated within a year.

Level of social participation was calculated as follows:

| | Number of Programs (N) | Frequency (f) |
|---|---|---|
| 1. Number of agricultural extension programs respondents participated within a year | - | - |
| 2. Number of agricultural organization respondents affiliated and participated | - | - |
| Total | | |

If the average number of their participation both in agricultural extension programs and agricultural organizations was more than 8 times, it was considered as "high level" of social

participation. If the average number of such times was less than 7 and more than 4, it was considered "moderate level" of social participation. If both activities were less than 3 times, it was considered "low level" of social participation.

$$\text{Average number of participation} = \frac{N \times f}{2}$$

| Level of social participation | Ave. number of participation |
|---|---|
| High | More than 8 |
| Moderate | 7 - 4 |
| Low | Less than 3 |

# CHAPTER II

# THEORETICAL FRAMEWORK

## Technology Generation

It appears that food production in developing countries is subject to traditional technology which could not be optimal (Evenson, 1975). It is expected that the introduction of new technologies would increase agricultural production in developing countries. The development and diffusion of high yielding rice varieties had contributed to increased rice production in most of the developing countries (Herdt and Capule, 1983; Rhoades, et al., 1983; Cleaver, 1972). However, much of the past experiences over the last several decades in transferring new technologies to developing countries came up against realization that offered technologies often had little or no advantage over the traditional methods under the economic, social and climatic conditions facing the farmers (Evenson, 1975; Horton ,1983). It had also been found that many past attempts to transfer new technology failed as they either did not solve economically important problems or because farmers were reluctant to adopt them due to social unacceptability of the technology (Horton, 1981; CIP, 1981; CIP, 1984). Therefore, the need for development of appropriate technologies in considering both agro-economical and wider social context is now accepted widely within technology-generating research institutions (Barlow, et al, 1983; ICRISAT, 1980; Flinn, 1978). Moreover, Biggs (1976) reported that technological information generated in international research centres was not spreading equitability to the farmers of developing countries as fast as expected. Sometimes, technology development had often led to unanticipated implications (Rhoades, et al., 1983).

### Process of Technology Generation

New technology development must be dynamic and flexible and the strategy must start with need assessment of the end-users (Woods, 1977; ICRISAT, 1980; Rhoades and Booth, 1982). It is not an easy task to generate technologies which are appropriate in every aspect. Moreover, particular needs of the technology may change over time and space. It may also happen that the original technology becomes obsolete and replaced by more appropriate technologies (Woods, 1977; Rhoads, et al., 1982). Offered appropriate changes may not be appropriate as perceived by the farmers themselves (Hildebrand, 1980; Werge, 1977). As indicated by Hildebrand (1980) one of the reasons why small farmers do not accept changes in their existing farm systems as expected by the developers was the piecemeal fashion orientation of technology

generation and diffusion strategies adopted by various disciplines in order to develop a technology which was not acceptable to the end-users. Ashby (1982) suggested that failure of agricultural technologies to diffuse can often be attributed to the location-specificity of technology. This idea was supported by Jarrett (1982). It seemed that there was an observable gap existing between the available technology to the farmers and the kind of technology really needed by them to solve existing agricultural problems within their own agro-socio-economic settings.

Woods (1977) and Hilderbrand (1978) suggested that the development and transfer of acceptable technology must involve multidisciplinary team approach including intended clientele - the farmer. Until recently, few attempts had been made to develop technologies on this school of thought. In identifying suitable rice production technologies for small farmers in Nigeria, Bartlett (1983) suggested that interactive cooperation of multidisciplinary teams could be used successfully in making recommendations acceptable to farmers. Farmers' collaboration throughout the whole process of designing, execution and evaluation of new technologies had been regarded successful and had strengthened the dialogue between farmers, extension workers and researchers (Icaza and Lagermann 1983; IDRC, 1984).

Rhoades and Booth (1982a) suggested an interdisciplinary approach in the identification, generation and transfer of accepted storage technology. It emphasized the active involvement of farmers, biological scientists, social scientists and other disciplines as a team working together toward the identification of problems, designing, generation and evaluation of agricultural technology. This approach pointed further that generating acceptable agricultural technologies to solve farmers' problems should begin and end with the farmers. This "Farmer-back to-Farmer" model also suggested the importance of continuous interactive activities between and among the different disciplines involved in technology development in order to develop an acceptable farmer-oriented technology, and identify the proper research needs.

Sanders and Lyman (1982) indicated that research process proceeds from the experimental station to regional trials and finally to on-farm research trials. It was often seen that most experimental station conditions where technologies developed were quite different from the farmers' field conditions (Hildebrand 1980; Byerlee, et al., 1979; Chambers and Ghildyal, 1985). Therefore, it is expected to have wide variation of performance of a particular technology under farmers' conditions. Biggs (1980) reported that farmers do informal research about new technologies in order to evaluate it under their own setting. Farmers may select some component of a package of technology (Biggs 1980; Rhoades, 1984a) for integration with their farming practices. Therefore, on-farm research activities may play an important role

in the process of technology generation to its final adoption (Cortbaoui, 1981; Biggs, 1980; IRRI, 1977). It was observed that farmers' involvement with the other disciplines who engage in technology generation process is a vital component for the development of an appropriate and an acceptable technology which can be put into practice particularly in the farming systems of developing countries (Rhoades and Booth, 1982a; Biggs, 1980; Hildebrand, 1978; IDRC, 1984). It also scrutinized the cost and time taken for development of such technologies (IDRC, 1984).

### Transfer of Technology

Conventional transfer of technology from developed countries to developing countries had exhibited several unexpected discrepancies and consequences, and a growing concern to change this approach is needed (Biggs, et al., 1983; Sparks, 1983; Chambers, 1985). Traditional unilinear model of transfer of technology from research via extension to farmers had been criticized for its relevance and applicability (Whyle, 1981; Cuyno, 1984). Horizontal feedback model involving farmers and extension service in research process in technology generation, in spite of its improved communication flow in comparison with unilinear model had also been viewed as a weak and still linear model which isolate the farmer as passive recipient of the technology (Rhoades and Booth, 1983).

## Diffusion of Agricultural Technology

A steady increase in agricultural production through technological changes in the farming systems is indispensable to economic growth. Moreover, it is essential that agricultural researches generate new technology within the condition found in a particular locality that would facilitate higher production. It is also necessary that these technologies must reach the ultimate end-users if they are to be put into practice and benefits are to be realized. Therefore, the process of diffusion of technology plays an important role in disseminating new technology and practices.

Generally, when new technologies are introduced to the farmers, considerable time elapses before a new technology is adopted and utilized by them (Ashby, 1982; Lionberger, 1960; Rogers, 1962; Mohammad and Majud, 1979; Barlow, et al., 1983). Diffusion of technologies over time had been viewed as an aggregate outcome of many decisions made by the individual farmer (Barlow, et al., 1983). Individual decisions are influenced by several social, economic, psychological and physical factors (Mohammad and Majud, 1979; Wirasinghe, 1977; Malla, 1983; Shakya, 1983; Abd-ella, et al., 1981). Apart from these factors, characteristics of the new technology or practice and their

influence on diffusion also had been studied (Rogers and Shoemaker, 1971; Ashby, 1982). Diffusion of new technologies followed a certain pattern which is exhibited over time. Earlier work of Griliches (1957) showed that adoption of hybrid corn varieties by farmers was slow at the beginning and the rate of adoption was increased at a higher rate as the time elapses and followed a sigmoid curve and there was considerable difference between separate curves for each location. Later adoption studies also supported these sigmoid shape adoption curve (Shetty, 1966; Sumayao, 1969; Palmer, 1974; Islam and Halim, 1976; Huke, et al., 1980). However, Cheong (1973) reported that no such trend was observed for Tongil rice adoption in Korea within two years after introduction of new rice varieties. Wide variations in adopting new technologies after introduction had been studied (Huke and Duncan, 1969; Murshed and Alam, 1978) and some farmers were found to take four years to adopt a particular technology fully (Bari, 1974) while others only 4 months (Liao, 1968, Pachio and Ashby, 1983).

Diffusion of an innovation within a farming system also may be influenced by the communication network existing in that system. Rogers and Shoemaker (1971) viewed diffusion as a process by which certain innovations are communicated through certain channels over time. New technologies may diffuse even without involvement of an extension activity to those who can reap the benefits from it and who possess both knowledge and resources to apply it (Roling, 1984). Much of the earlier diffusion researches viewed the earliness of adoption as a socio-psychological trait of farmers (Rogers and Shoemaker, 1971). Early adopters were said to be more progressive than the late adopters and usually had larger farms, higher level of education, more contact with extension agents and had access to more information (Wirasinghe, 1977; Rogers and Shoemaker, 1971; Shakya 1983). However, Roling (1984) and Monu (1983) suggested that earliness of adoption may be due to relatively high access to resources rather than venturesomeness of early adopters.

Ashby (1982) conceptualized that early adoptors made the decision to adopt technologies under condition of uncertainty and farmers who adopt them later had access to information about their performance under local conditions which were obtained from the early adoptors and can make decision based on these information. She also indicated that the rate of diffusion of different technologies in different localities were varied depending on the technology and location. It was also found that a decision to adopt a new technology may be influenced even without knowing its characteristics and performance under local conditions as certain critical number of adopters had been attained in the farming community. She concluded that innovativeness among the farmers varied with the technology and the causal factors that would influence the farmers to adopt earlier or later stages were varied in the diffusion process.

It was assumed that diffusion of a technology among farmers would allow trickle-down process from progressive farmers to less progressive farmers. But this process revealed a wide variety of discrepancies. It was a leaky process (Castillo, 1983) with the content and the essence of the technology may be adulterating and distorting progressively as it reaches the recipient. It also contributed to the rapidly increasing gap between the rich and the poor (Roling, 1984). This approach may lead to ignorance of the majority of the resource-poor small farmers by the extension and preferential treatments of those who are categorized progressive farmers (Monu, 1983). Recent diffusion researches revealed that diffusion as an activity benefited only those who had access to resources (Monu, 1983; Roling, 1984) and they suggested that horizontal diffusion approach would benefit homogeneous target groups within the farming communities. Barlow, et al. (1983) found that profitability of the technology, resource constraints and risk factor are important economic variables that influence the diffusion rate of a particular technology. Apart from these economic variables certain social and technological factors may also influence the diffusion rate. Farmers rarely adopt complete technological package; they select some of the components and incorporate them into their present farming pratices (Horton, 1984).

## Adoption Behavior

Individual adoption behavior generally followed a heterogenous pattern. Accepting a new idea or a practice and its adoption may take few hours to many years depending on the individual, environment and the technology. Rogers (1962) and Lionberger (1960) found that some farmers may not adopt a particular technology at all. Some farmers respond to a particular technology faster than other farmers; while some farmers adopt the recommended technology fully, others adopt it only partially (Shakya, 1983; Liao, 1964). In understanding these individual differences in adoption behavior, Rogers and Shoemaker (1971), Lionberger (1960), and Beal and Bohlen (1957) suggested five stages of learning process explaining how farmers were to adopt or reject a particular technology.

## Adoption Process

At the awareness stage the individual farmer learns about the technology, but lacks adequate information. At the interest stage, the individual farmer may become interested about the new technology and seek more information. At the evaluation stage the farmer evaluates the technology within his conditions, expectations, resources and management, and decides whether or not to try it. The farmer tries this new technology on a smaller scale in order to assess its appropriateness to his conditions. At the last stage the farmer decides whether to adopt the

technology or reject it. Rogers and Shoemaker (1971) came up with a more comprehensive analysis of adoption process which emphasized the continuing nature of adoption of an innovation and having four functions. During the "knowledge function" the individual develops some understanding about the new idea and gathers information from various sources. During the "persuasion function" stage he forms an attitude toward the innovation and persuades himself or subjects himself to persuasion by others. At this stage it may involve seeking more information, interaction with others and even try out the new idea or practice and weigh alternatives for making decisions. Based on the attitudes formed during the previous stages, the individual may accept or reject the idea or practice.

During the "decision-making function" stage the individual may decide either to adopt or reject the new idea of production or delay the decision to allow further verification. Up to the decision making function, innovation - decision process remained as a mental activity. During the confirmation stage the individual may further justify the innovation decision he had taken from his experience with the new innovation or from others who adopted it. At this stage the individual may take decision to continue the adoption or discontinue it. Dixon (1982) concluded that time factor is involved in diffusion of innovation in two ways. Firstly, at the individual level as long as alternative practices exist, innovation-decision process occurs over time, and is never completed until the decision to adopt is subject to confirmation. Secondly, it takes time to diffuse an idea through a heterogeneous social system.

However, these stages may not necessarily represent the individual adoption process but they provide a sequence of mental and physical activities intervening in the adoption process (Lionberger, 1960). He also pointed out that decision sequence may be terminated at any point or stages may be blended. Studies of the learning process also recognized the social influences which exert from the society and the extension agent that would influence individual decisions to adopt a technology. Islam and Halim (1976), Battad (1973), and Pal (1969) reported the varying degree of time period taken to initiate awareness stage and to the final adoption stage. It is evident that the effectiveness of communication media and the extension activities play a vital role in disseminating the new technology.

Studies on the spatial pattern of adoption (Huke and Duncan, 1969; Cheong, 1973; Suh, 1976; Barker and Herdt, 1978) indicated that diffusion of new technologies over space is inconsistent.

## Adoptor Categories

Rogers and Shoemaker (1971) categorized adopters into "innovators" "early adopters", "majority", "laggards" and "non-adopters" depending on the time taken to adopt a particular technology or practice. Although these categories are arbitrary

each adopter category shows certain characteristics which are related to earliness or lateness of adoption. Within the context of diffusion model, farmers had been seen as major constraint in the development process and much of the studies have been focused to find out the distinction between innovators and laggards (Lionberger, 1960; Rogers and Shoemaker, 1971). Among their characteristics, independence, personal initiative, practical capabilities, and risk taking ability (Barlow, et al, 1983) were found to be associated with earliness of adoption of technology by farmers. Several other personal characteristics such as farmer education level (Mangahas, 1970; Chinnappa, 1977; Flinn, et al; 1980), extension contact (Hossain, et al., 1977; Wirasinghe, 1977), level of technical knowledge (Kol Shus, 1971; Bhati, 1975; Ramaswamay, 1973), family size (South, et al., 1965; Bhati, 1975; Yim, 1978), farmers' experience (Mangahas, 1970) and family aspirations (Wilkening, 1954; Adb-Ella, et al., 1981) were found positvely related to early adoption of recommended practices.

Socio-economic Environment

Apart from personal characteristics of the farmers, several socio-economic variables were also found to affect the adoption of new technologies. Furthermore, it was been argued that in explaining the adoption pattern, institutional constraints and social structural factors are much more explanatory and determinant than the personal characteristics of farmers (Hevens and Flinn, 1975). Farmers' participation in social organizations (Pascual, 1971) was found related to adoption of recommended practices as the organizations may provide relevant information and accessability to other resources (Herdt and Capule, 1983; Abd-Ella, et al., 1981; Rogers and Shoemaker, 1971; Bhati, 1975).

The number of economic variables that are affecting adoption behavior had been studied. Thus, differential in access to capital are seen as an important factor in explaining variations in the rate of adoption (Schutjer and Van Der Veen, 1977). Moreover, Abarientos (1975), Islam and Halim (1976) and Rajagopalan and Singh (1971) found that those with high income tended to adopt modern rice varieties first. This trend was supported by Lionberger (1960), Battad (1973), and Rogers and Shoemaker (1971). An increase in family income may influence the allocative efficiency of farmers to enable them to operate near the economic optimum. Non-availability of adequate capital resources is often considered as a determinant of the rate of innovation adoption. It has been reported that availability of credit is an important factor in the adoption of modern high yielding rice varieties (Librero and Mangahas, 1975; Wirasinghe, 1977). Introduction of new technologies demands capital investment. It may not incur as an initial cost only but also as maintenance cost. In the case of potato storage technology, no matter how simple the storage method is, it costs money and it adds to the total production cost (Booth, et al., 1982).

The relationship between farm size and adoption seemed to be inconsistent. Baker and Herdt (1978) and Ramaswamy (1973) found that small farm size leads to adoption of modern varieties while Kalirajan (1979) and Flinn, et al., (1980) claimed that adoption is equal among all farm sizes. But Beal and Sibby (1961) and Khan (1975) indicated that those who possess larger farm size tend to adopt new technologies sooner than small farm size owners. Rhoades (1984a) reported that small-scale potato farmers in Peru were eager to adopt new farming practices provided that the offered technologies had clear benefits and advantages over their current practices. The case of diffusion of diffused light potato storage technology in the Philippines showed that farmers' individual need for the change in their existing circumstances influenced the adoption of the technology irrespective of their farm size (Acasio, 1984).

## Characteristics of the Technology and Adoption Behavior

Certain technological innovations are adopted relatively at a fast rate. It appears that farmers tended to adopt certain technologies depending on the performance of the technology under local conditions, available resources, and environmental constraints. Ashby (1982) discussed that relative adoption of a certain technology among farm resource groups at a given stage in the diffusion process also varies with the technology. Thus, suitability of technologies to local condition may be considered as variable in the diffusion process.

Rogers and Shoemaker (1971) described five attributes which characterized the innovations, namely: relative advantage, compatibility, complexity, trialability and observability. These specific characteristics may influence the rate of adoption of technologies. Schutjer and Van der Veen (1977) also considered four characteristics of a particular technology related to its adoption: efficiency of the technology on net farm income, factors' intensity on use of factors of production, complexity of the technology and diversibility of the technology. They also reported that adoption of high yielding wheat varieties showed that the potential existence for divisability facilitated farmers to adopt the new variety in spite of the package recommendation. Van Uyen and Vander Zaag (1984) reported that simplicity of the technology and low initial cost and fast production rate and high yields were the main characteristics that influenced the adoption of rapid multiplication technology for potato production in Vietnam.

Various researchers reported that the complete package practices of farm innovators would produce high yields (Allan, 1971; Moock, 1973). However, Horton (1984) reported that technological package often failed to perform well under local conditions due to agroeconomic constraints prevailing in the local

setting. Rhoades, et al. (1983) reported that farmers did not adopt diffused light storage technology as demonstrated but they modified or altered the technology to meet their requirements.

## Impact of Technological Changes

The adoption of a new technology is expected to bring desirable consequences to the end-user of the technology and by doing so, little attention had been given to the unexpected consequence of adopting the technologies (Shingi, et al., 1981; Goss, 1979; Cleaver, 1972). It was seen that technology change processes in farming systems developed numerous agro-socio-economic consequences that were never expected when the technological changes were developed and diffused to the end-users (Rhoades 1984b). Studies revealed that capital intensive technology tended to increase existing inequalities (Jhunjhunwalla and McPherson, 1972; Gotsch, 1972;, Hevens and Flinn, 1975). The introduction of modern rice varieties had increased the labor input per hectare but decreased the labor input per ton of rice produced (Barker and Cordova, 1978). It also increased the total rice production and yield per hectare (Herdt and Capule, 1983) and unequal distribution of income (Herdt and Wickham, 1978). However, increased production and income levels had also contributed to increased standard of living (Shingi, et al., 1981; Rogers and Shoemaker 1971).

It was also found that the adoption of new rice technology brought about a new outlook in agriculture and developed farmer's new attitudes, aspirations, perceptions and anemities in life (Castillo, 1975). The consequence of the adoption of a new technology may not necessarily occur only exclusively to the adopters but also to non-adopters as well (Goss, 1979).

Ruthenberg (1980) described farming as a system and several activities are related to each other by common use of the farmers' resources and limits management capability. Therefore, any change in the present agricultural practice may affect the changes in other activities in the system (Berlow, et al., 1983; Shakya, 1983; Wirasinghe, 1977). Introduction of new potato varieties to Andean regions in Peru had altered or modified the traditional storage practices (Rhoades, et al., 1983). Adoption of diffused light storage techniques for seed potato storage in Sri Lanka resulted in the change in the planting season and increase in yields due to availability of good quality seeds at proper planting time (CIP, 1983). Substantial economic advantages of true potato technology may accompany increased labor requirement for production of seedlings (CIP, 1983). Van Uyen and Vander Zaag (1983) reported that the use of rapid multiplication technique for potato production did not only reduce the seed cost but also begin to replace degenerated seed stock, reduce storage losses, popularize new varieties and demand for training activities about the technology.

The CIP (1984) reported that the introduction of DLS technology in Sri Lanka had brought about several observable impacts on the potato production system. Apart from the yield increase, changes in the cropping system, alteration of seed flow between farmers, reduction of seed storage losses and curtail seed importation from other countries had been observed. It also revealed that this technology did not only have an impact on potato production but also on other crop production systems as well.

## Interactions and Role of Communication

The flow of technology and knowledge from the time they were generated to the time they reached the end-user is a vital process which can enhance agricultural production. Shetty (1966) reported that it is not the lack of technologies or knowledge that limits this but the farmers' willingness, need and ability to accept the technologies and knowledge. Earlier conceptualization of this process as a research-linking-direct system (Rogers and Jain, 1969) had been criticized by various workers for its linearity - knowledge having only from research to user (Gildeonse, 1968; Guba and Clark, 1975), one way communication "down" through the system (Cummings, 1977) and its dependency relationship between the user and the researcher rather than a collaborative activity (Cumming, 1977; Roling, 1973; Darling, 1977). Another criticism on this school of thought was the assumption of technology transfer rather than an interactive communication process (Castillc, 1983; Roling, 1973) resulting in adaptive, appropriate or acceptable technology. Moreover, Ruttan (1975), Castillo (1983), and Roling (1982) pointed out that dependence on trickle-down process of communication through the farming system as an extension strategy had unjustified and lacking in distributive effect to all members of the system where it was introduced.

In this context, the challenge in transferring agricultural technology to farmers was indeed to create effective linkages between farmers and the systems, capable of providing the necessary technologies (IDRC, 1984). It was also expected to perform the effort of linkers or translators with a "dual understanding" (Beal and Meehan, 1978) of scientific knowledge and the practical conception of the problem. Generally, extension personnel were expected to act as linkers and interact with farmers and research system in order to disseminate and communicate the idea or technology. Activities in this phase usually included an understanding of the technology and its uses, designing strategies for dissemination and communication, adaptation and monitoring and evaluation under farmers' conditions (Beal and Meehan, 1978).

More often technology development and technology transfer were viewed as separate functions but these two functions are one process (Castillo, 1982). It is also seen as a complicated,

interactive and iterative process. Therefore extension system alone as a linkage between research system and farming system may not ideally be equipped to perform this complex task successfully. In this context, effective communication and interaction between and among farmers, extensionists and researchers play a vital role in the process of technology generation, integration, adaptation, dissemination and utilization.

Beal and Meehan (1978) suggested an iterative dynamic model of knowledge production-utilization in agriculture. The model illustrated the repeated interactions and communicative activities as important aspects of every stage of knowledge production and utilization process.

The farmer-back-to-farmer model suggested interdisciplinary approach in technology development and its adoption involving continuous interaction and communication between and among farmers and various disciplines (Rhoades and Booth, 1982).

These two models explicitly emphasized the interaction and communication of the various sectors concerned from the initial problem identification up to technology development and back to be used by the endusers. Technology development as the part of researchers and the transfer of technology as the responsibility of extension never terminate at that level. They are not separate functions but a one or combined process. Therefore, the interaction and communication process between and among farmers and other disciplines involved in technology generation and dissemination may help in understanding the farmer and his conditions, the adaptability and suitability of the technology under these conditions and how the technology is perceived by the farmers in the research process (Rhoades, 1984; Chamber, 1980). Because of the complexity of the process of technology generation and its ultimate use, there may be several patterns and nature of interactions and communications with varying degrees between and among these disciplines.

## Overview

The introduction of new technologies is expected to bring about increased agricultural production in developing countries. However, past experiences in this effort revealed that offered technologies often failed to perform as expected under farmers' actual situations due to various reasons. Therefore, there had been a growing concern over the development of appropriate technologies considering both agro-economic and wider social context of farmers in technology-generating agricultural research institutions in order to develop technologies which would be put into practice under farmers' conditions (Burton and Booth, 1982).

The burgeoning interest in the development and dissemination of appropriate technologies reflect the recognition of the essential role of technology in agricultural development particularly in developing countries.

In this venture it is important to understand the farmer and his conditions before designing any technology. It is also important to consider that available technologies may need to be subjected to "fine-tuning" before being adapted to a particular farming system.

In this context, Rhoades and Booth (1982) and Chambers and Ghildyal (1985) suggested that in generating technologies farmers' collaboration with other disciplines throughout the whole process of identifying the problem, designing a probable solution and executing and evaluating the technology as an interactive interdisciplinary activity would bring about an appropriate technology in an acceptable form. However, it is not possible to generate universal technologies which could operate everywhere equally well as expected.

This interdisciplinary relationship as shown in the conceptual model in Figure 2.1, does not terminate at the technology development stage but it is a continuing activity even after the subsequent sustained adoption process.

It is also necessary that these technologies reach the end-user if they are to be put into practice. There are a number of different sources of agricultural information and different means and strategies for disseminating these information to end-users. During this process farmers may further evaluate and adapt different technologies in various aspects in order to fit them into their setting. However, farmers' objectives in adopting new technologies are more complex than increasing production.

Diffusion of technologies over time had been viewed as aggregate outcome of many decisions taken by an individual. Individual decisions to adopt a certain technology may be influenced by several factors, namely: social, economic, psychologial and physical.

Technology diffusion and adoption processes may vary in different dimensions among farmers due to various conditions and constraints within which the farmers operate. Apart from this, characteristics of the technology also affect these variations to a certain extent.

Therefore, testing of technologies at the farmers' level is an important component of research process especially in developing countries where communication link between farmers and research is weak. Farmers often do not possess adequate information and competencies in combining or modifying the technological changes to their own environmental and production system.

Adoption of a new idea is the consequence of a series of human relations. Therefore, insights unto the nature of interaction and communication flow between and among the farmers and other disciplines involved in technology generation and dissemination would help in understanding the diffusion and adoption process in a farming system.

Technological changes in existing farming systems are expected to bring about desired changes. These changes may also develop numerous unexpected agro-socio-economic impact that were never anticipated when the technological innovations were developed and diffused to the end-users. Any change in agricultural technology in a particular crop or practice may affect the changes in other activities in the farming systems. Therefore, the new technology changes must fit into the existing agro-socio-economic systems of the farmers (Fig. 1).

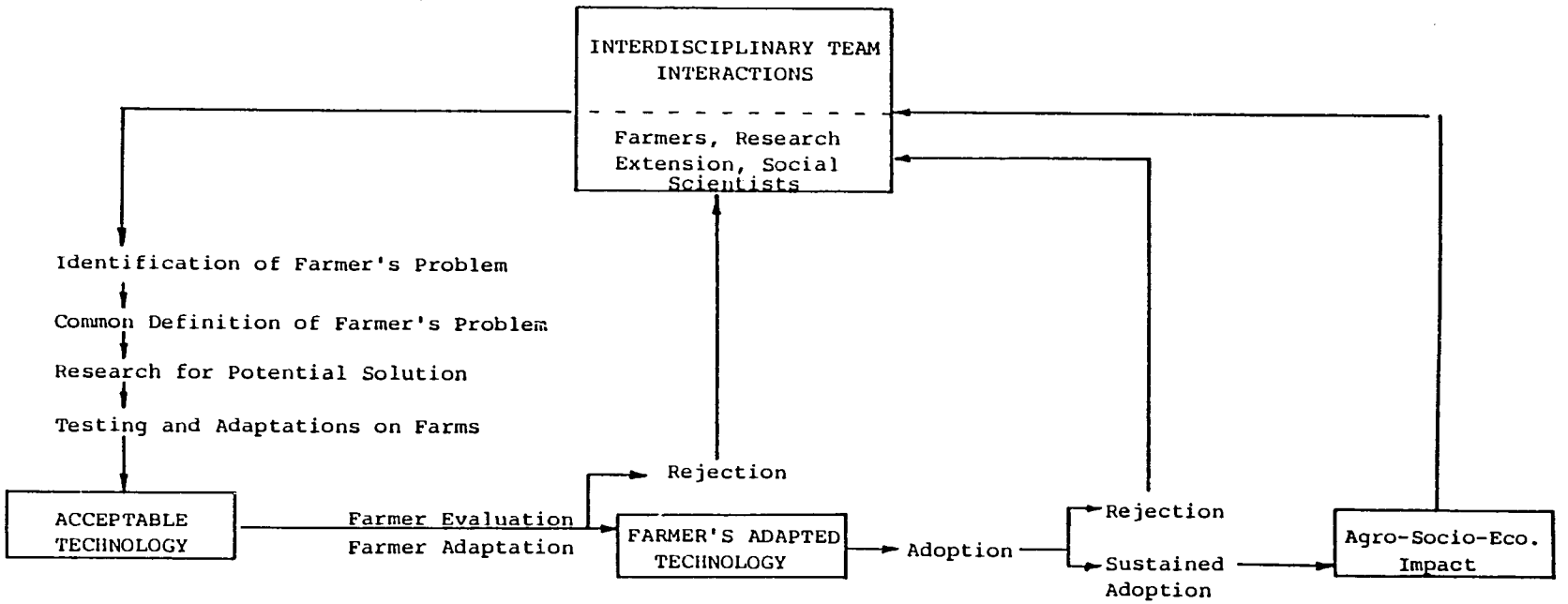



Figure 1. Conceptual model of generating farmer's acceptance technologies, diffusion and adoption. (Adapted from: Farmer-Back-to-Farmer Model of Rhoades and Booth, 1982).

# CHAPTER III

# METHODOLOGY

## Locale of the Study

The study was conducted in Badulla district in Sri Lanka where potato crop has been grown for the last two decades. Most of the farmers in the upper part of the district are small farmers and they possess less than two hectares of cultivable land, both paddy and highland. Agro-climatic conditions are conducive for vegetable and rice cultivation. Rice cultivation is limited to Maha season and production is mainly for home consumption. Other important crops like potatoes, beans, cabbage, Brinjal, pumpkin, raddish, capsicum and tomato are grown both under the rainfed and irrigated conditions for commercial purposes. Nearly 2500 hectares are planted to potato in this area annually. Ten Agrarian Service Centers (ASC) are located in this area for extension and other support services. The study area is shown in Fig. 2.

The main reasons for the selection of this particular area for the study were:

1. More than 50% of the potato production is concentrated in this area (Albert, 1984) and majority of the farmers produce seed potatoes and store them in their farms.

2. DLS technology was introduced in this area in 1979 and considerable adoption of the technology had been observed and agro-socio-economic implications were emerging.

3. A number of extension programs were carried out in this area in order to disseminate the DLS Technology.

## Unit of Analysis

The unit of analysis was the individual potato farmer in 10 agriculture service centers in Badulla district. However, since farming activities are complex but interrelated activities of a subsystem in the farming system, additional data were also gathered from other members of the family who were engaged in farming activities. Extension agents, research personnel, village leaders and other government officials were interviewed for additional information.

## Sampling Procedures

There were about 900 DLS technology adopters in this area. Farmer respondents were selected from the list of adopters of DLS

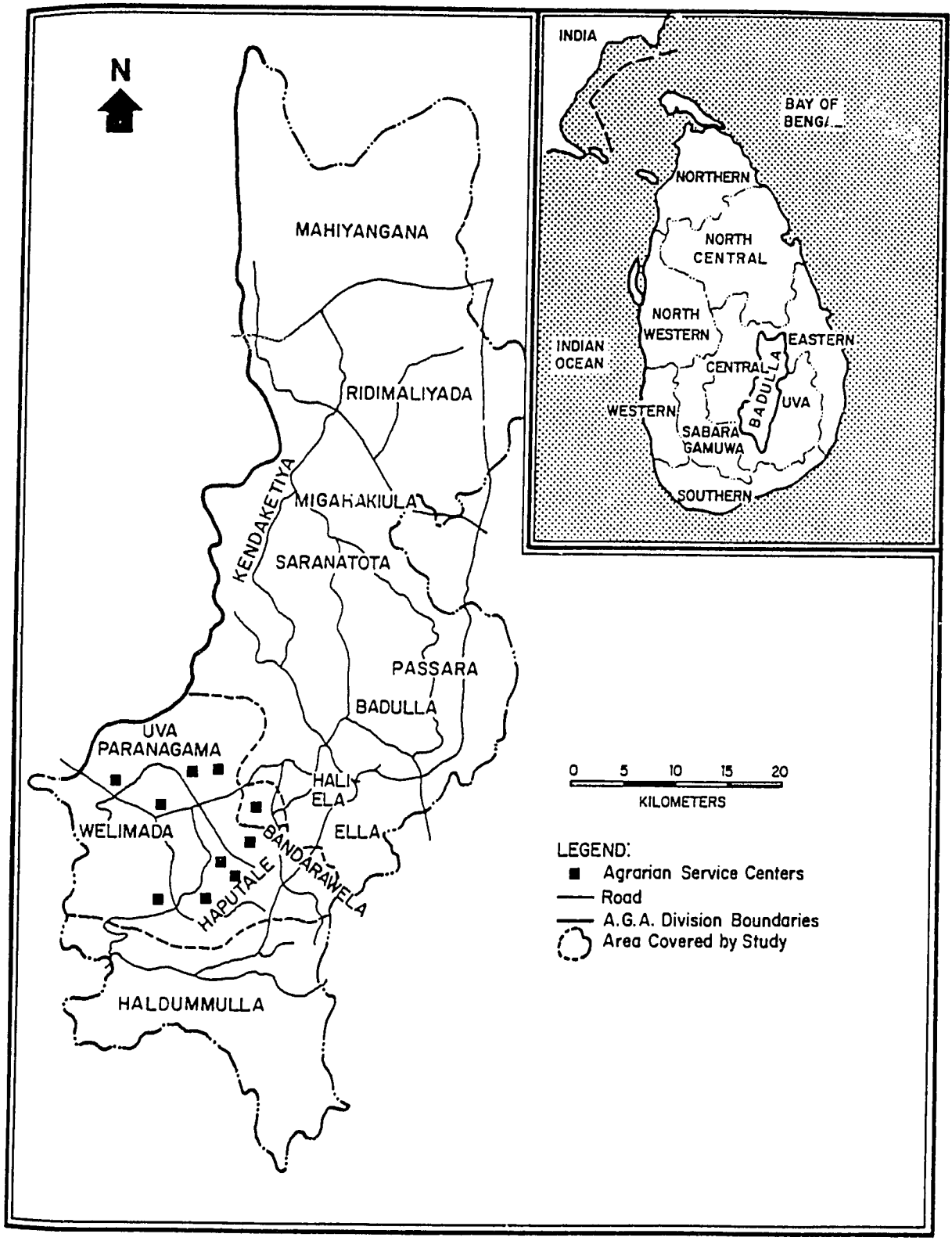



Fig. 2. Map of Badulla District showing the Study Area.

technology in the 10 ASC areas prepared by the extension office. A self weighting multi-stage sampling technique was used to select 105 farmers from ten ASC areas.

1. On the first stage a listing down of all DLS adopters was made for each ASC area.

2. On the second stage lists of adopter farmers were made for each ASC area according to the following criteria:

   a. those who cultivate at least two potato crops per year;

   b. those who used DLS technology for at least one year.

3. Finally twelve percent of the total number of selected farmers in each ASC area was selected by random sampling. A list of alternative respondents was obtained just in case of unavailability of respondents.

A sample of 30 non-adopters, representing three farmers from each ASC area was selected through simple random sampling from the potato farmers' list provided by the ASC.

All the agricultural extension agents of the study area who were engaged in disseminating DLS technology during the period 1978-1984 were included in the sample. Further, all the research personnel engaged in adaptive research activities in the study area were also included in the sample.

In order to get in-depth information on important aspects of seed storage practices and interaction patterns of technology diffusion, 10 key informants were purposively selected representing one from each ASC area.

Table 1 shows the number of respondents included in the sample on different respondent types.

Table 1. Number and type of respondents in the sample.

| TYPE OF RESPONDENTS | NUMBER |
|---|---|
| Adopters | 105 |
| Non-adopters | 30 |
| Extension agents | 30 |
| Reserch personnel | 3 |
| Key informants | 10 |
| Total | 178 |

## Data Collection Procedures

Data were collected using several methods: interview schedule, personal observations, inspection of records, and informal interviews. The interview schedule was pre-tested for its validity. After pre-testing, necessary adjustments were made before the actual collection of data from farmer respondents. The interview schedule was translated into Sinhala language. Two interviewers were trained by the researcher in order to gather the data correctly from the farmer respondents. Cross checks were made frequently with researchers in order to correct any discrepancy. Personal observations were done in order to get relevant information on storage practices which were difficult to get by the other methods.

Non-adopters were interviewed in order to get information on present seed storage practices, problems and advantages of their present storage systems and the reasons for non-adoption of DLS technology.

Examination of records pertaining to potato production and seed supply were carried out. These information were gathered from the institutions and organizations involved in potato production and seed distribution.

Informal interviews with extension personnel, research personnel and key informants in villages were carried out in order to get information regarding the interactions and communications that took place in developing and disseminating the DLS technology.

## Statistical Analysis of Data

The data were statistically analyzed and interpreted in relation to the objective of the study. Frequencies, means, percentages and ranking were used to analyze some aspects of the variables. However, chi-square test was used to find the correlation and association between variables. The five percent level of probability was considered as the level of significance.

### Logistic Model

The logit model was used to predict the factors associated with probability of adoption of DLS technology. The model is based on the cumulative logistic probability function.

$$Pi = \frac{1}{1 + e - ( + \quad xi)}$$

where = P = probability of adoption of DLS technology (dependent variable)

e = base of natural logarithm = 2.718

= intercept

= maximum likelihood estimate coefficients

xi = explanatory variables (independent variable)

Details of the parameter are given in Appendix F.

# CHAPTER IV

## RESULTS AND DISCUSSION

The first part of this chapter describes the agro-socioeconomic environment of the family farming units in the study area. It is followed by a brief description of the existing cropping patterns of the area. Traditional potato storage methods and practices, some of the potato seed storage problems encountered by the farmers, various seed sources and utilization of potato seeds after and before adoption are discussed in the later part of this chapter. Lastly, the involvement of family members in seed storage practices was discussed.

Part two of this chapter discusses the DLS technology adoption processes. It also focuses attention to adoption behavior of the farmers, information sources on DLS, farmers' perceived characteristics of the DLS and structural modification and adaptations made during the process of technology generation. Farmers' reasons for non-adoption and their assessment of DLS in terms of agro-socioeconomic aspects were also discussed. Probability of adopting DLS technology under farmers' agro-socioeconomic setting are also analyzed using a Logit model. The final portion of this part is devoted to the description of the diffusion process of DLS among farmers in the study area.

Analysis of interactions and communication between and among farmers, extension agents and research personnel during the process of technology generation, adoption and diffusion processes were described in the third part of this chapter.

The last part of the chapter describes some of the agro-socioeconomic impact of DLS technology adoption on farming system of the area at its simplest level.

### Socioeconomic Environment of DLS Farmer Adopters

In this section, some socioeconomic characteristics are discussed in order to understand the general profile of the adopters.

#### Family Size

In calculating family size, only family members who were engaged in farming activities in the farm were taken into consideration and grouped accordingly. This gave an indication of family labor availability for agricultural activities of the farm family units. Table 2 presents the distribution of farm family units.

The mean farm family size was 5.3. The majority of the farm families belonged to the medium-size families (67%) with 5-6 members. Seventeen farm families included one or two outsiders as helpers or workers during the peak seasons. There were also nine extended families in which paternal and maternal parents lived with the farm family but they seldom contributed to the labor force of the family.

Table 2. Family size of farmer adopters (N = 105).

| SIZE | NUMBER | PERCENT |
|---|---|---|
| Small family (2-4 members) | 16 | 15.2 |
| Medium family (5-6 members) | 70 | 66.7 |
| Large family (7 members and above) | 19 | 18.1 |
| Total | 105 | 100 |

Sex Composition of Farmer Adopters

One hundred one or 96 percent of the respondents were males and the rest were females. This did not categorize the typical DLS adopters to full extent due to the fact that adoption of DLS was not attributed to a single person activity in the farm family. It merely represents the sex composition of the household head as he or she is usually considered the adopter of the family unit.

Age

The age range of the farmer adopters was from 20-70 or an average of 43.3 years. Seven farmers were above 61 years old; they were mainly engaged in the less tedious work in farming. However, they made important decisions in the farming operations. This showed that there existed a rich tradition of taking necessary advice and opinion in farming operations from elders of the family. Section B of Table 3 shows the age structure of the farmers.

Educational Attainment

Only five respondents had no schooling while about 95% had an average of 6.3 years of schooling. Two persons had university education. Of the 29 farmers who had more than 10 years of schooling, 11 were part-time farmers. This information suggests that the higher the educational level, the less likely that they take farming as their main occupation. It was found that six farmers had vocational training in agriculture. Table 3 section C shows the educational attainment of the farmers.

Table 3. Some personal characteristics of the farmer adopters (N=105).

| VARIABLE | NUMBER | PERCENT |
|---|---|---|
| A. Sex | | |
| Male | 101 | 96.19 |
| Female | 4 | 3.80 |
| Total | 105 | 100.00 |
| B. Age structure | | |
| 20 - 30 years | 16 | 15.23 |
| 31 - 40 years | 27 | 25.71 |
| 41 - 50 years | 33 | 31.43 |
| 51 - 60 years | 22 | 20.96 |
| 61 - 70 years | 7 | 6.67 |
| Total | 105 | 100.00 |
| Mean : 43.31 | | |
| SD : 11.28 | | |
| Range : 20-70 | | |
| C. Level of educational attainment | | |
| No schooling | 5 | 4.76 |
| Grade 1 to Grade 5 | 33 | 31.43 |
| Grade 6 - General Certificate of Education ordinary level (GCE) | | |
| GCE (adv) level or technical qualification | 27 | 25.71 |
| University | 2 | 1.90 |
| Total | 105 | 100.00 |
| D. Years of experience in potato production | | |
| Less than 10 years | 11 | 10.5 |
| 11 - 20 years | 50 | 47.5 |
| 21 - 30 years | 44 | 42.0 |
| Total | 105 | 100.00 |
| Mean years of experience | 16.8 years | |

## Farming as Main Occupation

Out of 105 farmer adopters, 11 (10.5%) considered farming as an additional occupation since they were government employees. Although they got a better income from potato farming, no one among them was willing to give up or terminate their government positions. Apparently, the regular flow of wages and certain privileges derived from government employment supported and/or supplemented their farming activities to a considerable extent and because of these they gained a high social position in the farming community. Furthermore, because of their employment, these farmers had more access to seed sources (especially government seed sources) information and credit than the rest of the farmers. These were evidenced by the fact that six of these employee-farmers had larger DLS storage capacity (from 2-6 tons).

## Experience in Potato Production

The majority of the farmer adopters (72%) had more than 15 years of experience in potato produciton. Their average years of experience was 16.8 years (Table 3, section D). The shortest experience was four years, while the longest, 30 years. Because of this long years of experience, obviously these farmers would have better understanding about problems encountered in potato production as well as potato seed storage. It was also evident that the farmer adopters had evaluated the DLS, based on their previous experiences and problems associated or involved with the traditional potato seed storage methods.

## Family Farm Size

In considering the family farm size, all arable lands belonging to the family were considered. Although there were a number of tenurial patterns operating in the area, the majority (79%) of the farmers were found to be owner-operators. Classification of lands were made according to the topography, availability of water and seasonal utilization. Lowlands are usually irrigable paddy lands. Highlands and homestead lands are composed of irrigable and non-irrigable lands situated above the paddy lands and around the farmers' house. Chena lands or dry highlands are situated away from the farm house. They were usually rainfed and cultivated only once a year particularly during the wet season. The size of landholdings and types of arable lands are presented in Table 4.

Almost all of the farmers owned all the types of arable land except Chena lands where only 95 farmers owned them.

Lowland Paddy Lands

Table 4 shows that the majority of the farmers (71) owned less than 0.5 hectare of lowland paddy while only few (5) farmers owned more than 2 hectares. Average size of lowland paddy was only 0.65 hectares as compared to only 0.5 hectares of highland. Lowlands were planted to paddy during the Maha season (wet season) and then followed by potato and other vegetable crops in the Yala season (dry season). Furthermore, potato crops raised in lowland during the Yala season find their way to the market. This was the predominant cash crop in the farming system in the area. Hence, any change in the area cultivated in this type of land would have significant change in the total potato production, as well as total income of the farm family.

Highland

As many as 72 farmers owned less than 0.5 hectares while only 3 farmers owned more than 2 hectares or an average land size of 0.5 hectares (Table 4). Potato and other vegetable crops were grown on these slopping hilly lands in Maha season (wet season) under rainfed conditions. Potato crop raised on these lands were considered as seed crops and a larger portion of the harvest were used to plant the lowland areas during Yala season (dry season) under irrigated condition.

Homestead Lands

The farmers' houses were situated in these lands which were generally adjacent to the paddy lands. In comparison to other categories of land the average size of homestead lands was small (0.2 ha). A variety of vegetable crops are grown in this land irrespective of the season were mainly for domestic consumption. The relatively small size of lands (0.2 ha) posed as another serious constraint in the expansion of potato cultivation on these lands. It was found that only 15% of the farmers cultivated potatoes on these land. The majority of the farmers (93) possessed less than 0.5 hectares of homestead land while only three farmers were endowed with more than 1.5 hectares of homestead land.

Chena Lands (Dry Highlands)

This type of lands is highland, usually situated far away from the farmers' house. These lands are government-owned and encroached by farmers for cultivating short-term crops such as potato, pulses and other vegetables. A relatively more fertile than the other lands, Chena lands are generally cultivated in the wet season. Only 86 farmers possessed these lands with an average size of 0.5 hectares. Farmers harvested a better potato crop on

Table 4. Distribution of farmer adopters according to land size and type of arable lands (N=105).

| SIZE OF LANDHOLDING (ha) | TYPES OF ARABLE LAND | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lowland | | Highland | | Homestead | | Chena land | | Total Land | |
| | (N) | % | (N) | % | (N) | % | (N) | % | (N) | % |
| Less than 0.5 ha | 71 | 67.6 | 72 | 68.6 | 93 | 88.6 | 86 | 90.5 | 12 | 4.8 |
| 0.6 - 1.0 ha | 19 | 18.1 | 14 | 13.3 | 9 | 8.5 | 6 | 6.3 | 29 | 27.6 |
| 1.1 - 1.5 ha | 8 | 7.6 | 15 | 14.3 | 3 | 2.9 | 2 | 2.1 | 33 | 31.4 |
| 1.6 - 2.0 ha | 2 | 1.9 | 1 | 0.9 | - | 0 | 1 | 1.1 | 10 | 9.5 |
| 2.1 - 2.5 ha | 0 | 0 | - | 0 | - | 0 | 7 | 6.7 | | |
| 2.6 - above | 5 | 4.8 | 3 | 2.9 | - | 0 | - | 0 | 21 | 20.0 |
| Total | 105 | 100.0 | 105 | 100.0 | 105 | 100.0 | 102 | 100.0 | 105 | 100.0 |
| Average | 0.65 | | 0.5 | | 0.2 | | 0.5 | | 1.4 | |

Chena lands than in the highlands. The cropping practice in Chena lands was such that potato was grown only once a year but potatoes produced on these lands were mostly preferred as seeds by farmers to be planted in paddy lands during the Yala season.

## Total Lands

Having endowed with various types of lands seemed to be vital in sustaining and maintaining a continuous crop production system particularly in potato. For example, a major portion of the potato crop cultivated in the highlands and Chena lands during the Maha season (potato seed production is not feasible in lowlands during this season) was utilized for the subsequent Yala cultivation in the lowlands. This explains the existing harmony between the types of land, potato production and seed utilization in the present farming system.

## Cropping Pattern

The predominant cropping patterns of the study areas with respect to the land types are shown in Table 5.

All the farmers grow one crop of rice per year in the lowlands mainly for home consumption. It was clearly indicated that lowlands were intensively cultivated due to the availability of irrigation water. Potato crop may often be used as relay crop with pumpkins and sweet potato (74 farms) in lowlands. Otherwise potato may always be raised as a mono crop in other types of lands. Only 17 percent of the farmers were able to grow two crops of potato in Maha season, but almost all the DLS farmer adopters were able to raise at least two potato crops per year. There were consistent changes in the cropping pattern adopted by individual farmers. The cropping pattern depended on the availability of water, land and seeds. Detailed discussions on the changes that occurred in the cropping pattern is included under impact of DLS in the third part of this chapter.

## Cost of Production of Potatoes

In Table 6 the cost of production of potato per hectare is shown. In the Maha season the total cost amounted to Rs. 65904.23 based on the sample. The cost of seed materials was 57 percent of the total cost of production, while the other input cost was 25 percent. Labor cost was 18 percent and this included the hired and family labor.

The finding also revealed that potato crop demands highest capital investment as compared to any other crop used in their cropping system.

Table 5. Distribution of farmers according to the land type and the cropping patterns (N=105).

| LAND TYPE | CROPPING PATTERN | NUMBER OF FARMER ADOPTERS |
|---|---|---|
| Lowland | 1. Rice - potato - cabbage - beans | 13 |
| | 2. Rice - potato/pumpkin-cabbage sweet potato | 64 |
| | 3. Rice - potato - radish/sweet potato | 16 |
| | 4. Potato - rice - beans - capsicum | 12 |
| Highland | 1. Potato - beans - fallow | 76 |
| | 2. Potato - cabbage - fallow | 22 |
| | 3. Potato - legumes | 7 |
| Homestead land | 1. Potato - beans - fallow | 14 |
| | 2. Cabbage - beans - chilli | 17 |
| | 3. Cabbage - mixed vegetables | 74 |
| Chena land | 1. Potato - beans - fallow | 44 |
| | 2. Potato - legumes | 12 |
| | 3. Potato - fallow | 30 |

Table 6. Cost of producion of potatoes in Maha and Yala seasons (N=105).

| ITEM | COST RUPEES (Rs)* | % OF THE TOTAL COST OF PRODUCTION |
|---|---|---|
| A. Maha Season (Wet) | | |
| Cost of seed per ha. | 37750.00 | 57.28 |
| Cost of labour | | |
| i. Hired Labour | 4857.92 | 7.37 |
| ii. Family labour | 6896.31 | 10.46 |
| Other inputs | 16400.00 | 24.89 |
| Total cost | 65904.23 | 100.00 |
| Income (Ave. yield 8.5 tons/ha @ Rs 10,000.00/ton) | 85000.00 | |
| Average net profit | 19025.77 | |
| B. Yala Season (Dry) | | |
| Cost of seeds per hectare | 28037.50 | 44.90 |
| Average cost of labour | | |
| i. Hired labour | 9011.63 | 14.43 |
| ii. Family labour | 12792.47 | 20.80 |
| Other inputs | 12600.00 | 20.17 |
| Total cost | 62441.60 | 100.00 |
| Income (Ave. yield 10.5 t/ha @ Rs 9,000.00/ton) | 90000.00 | |
| Average profit | 27552.40 | |

*(Exchange rate 1 US$ = Rs. 28.70.

Comparing the cost of production for Maha and Yala seasons, there was a difference of Rs. 3200. The cost of seeds for the Maha season was higher than in Yala season. The reduction of cost of seeds in Yala season might have been due to the use of their own seeds for planting rather than purchased them from outside sources. Furthermore, the considerable increase in labour input (50%) in Yala season suggested the difficulties involved in intensive land preparation needed in lowlands during Yala for potato cultivation. The average yield for the Maha season was 8.5 tons per hectare while for Yala season was 10.0 tons per hectare. The average profit in Yala season was much more than the Maha season (Rs. 27558.40). These findings explicitly indicated that potato crop gave a higher income during the Yala season. In general also, income in potato production is higher than any other crop planted in Maha and Yala seasons (Albert, 1984).

## Sociology of Potato in Study Area

Obviously, a brief discussion on the sociology of potato in this area may not be sufficient, but it is pertinent perhaps to have an overview of the social context in understanding the prestigious position attached to the potato.

Potato crop was considered as the most expensive crop but the most profitable crop as compared to other crops in the area. In general, potato farmers were better off than other farmers. There were about 25,000 potato farmers in the island and 80 percent of the farmers in this area grow potato. They considered potato as the main income generating crop in this cropping system. They also believed that their level of living was relatively high because of the potato crop.

Potato crop involved high inputs, high risk but high return. Unlike other crops, potato had a ready market throughout the year. Storability of potato was an added advantage. Traders preferred to buy potatoes first than the other vegetable. Price fluctuation of potatoes in the buying and selling markets were not haphazard but gradual. But there was a considerable gap between producer's price and the consumer's price of potatoes.

Potato was considered as a prestigious crop not only by the farmers but also by the government and private sector organization. It had been given a wider and prompt attention when there were crisis and problems. Much emphasis had also given to research, extension and training on potato.

Potato was also a "political crop" in this area, with a great socioeconomic influence on all matters concerning daily life of people of this area. Household anemities such as radios, televisions, drawing room sets electrical items are often brought into the house following a potato harvest. Potato farmers

generally visited relatives or the holy places more than other farmers, indicating that they were relatively well-off financially.

Sometimes internal trade relationship within the farming community were done using seed potato. Owner-share cropper relationship was controlled and sustained by seed potato utilization and also land.

Ironically, per capita consumption of potato was very low (only 3.18 kg, Horton and Fugo, 1985) and as a food item it was considered a luxury, (Poats and Castillo, 1982). It was seldom included in the daily diet but it was a one-item in the menu when there were visitors at home. Potato was a relatively expensive food item in comparison with other vegetables. It is used as a curry in Sri Lanka diet rather than a main food.

However, farmers in this area consumed potato in almost every major meal as a curry and they keep their own potatoes for this purpose. Apparently, potato was the crop which brought wealth, health, social prestige and ultimately quality of life into the farming community.

## Storage of Seed Potto Before Adoption of DLS

It appeared that the practice of seed potato storage had existed in the area for quite a long time. After 1967, there was a steady expansion of potato crop as a result of restriction in importation of potatoes for consumption and demand for seed potato also had increased tremendously. However, seed potatoes were imported into the country for both Maha and Yala seasons until the late 1970s. Subsequently seed importation for Yala season was terminated due to import restriction policies of the government. During this period, farmers encountered certain difficulties in obtaining their total seed potato requirement.

This situation had motivated farmers to keep their own seeds for Yala season. Gradually, they developed their seed production system and storage methods.

Table 7 shows the cumulative number of farmer adopters who practiced seed storage before DLS adoption.

Seemingly after 1965, the practice of seed storage among farmers increased significantly. At the end of 1974, 45 percent of the farmers used their own seeds for Yala cultivation. In 1983, almost all of the farmers stored some amount of seeds for the Yala season.

Scrutinizing the records and informal interviews with village leaders and government officers revealed that there were

little efforts to encourage and disseminate this practice among other farmers during this period.

Table 7. Distribution of farmers who started seed potato storage before adoption of DLS (N=105).

| YEAR | NUMBER | PERCENT |
|---|---|---|
| 1960 - 1964 | 7 | 6.66 |
| 1965 - 1969 | 20 | 19.04 |
| 1970 - 1974 | 47 | 44.76 |
| 1975 - 1979 | 93 | 88.57 |
| 1980 - 1983 | 105 | 100.00 |

With regard to seed utilization before adoption of DLS it was revealed that 82 percent of the farmers stored seeds only for their own use while 18 (17.2%) farmers stored seed for planting and for sale (Table 8). Interestingly, four farmers revealed that they came to realize the possibility of selling excess seed and gaining extra income after one year's experience in seed storage. Table 8 shows the picture of this situation.

Table 8. Farmers' purpose of seed storage before the adoption of DLS (N=105).

| USE | NUMBER | PERCENT |
|---|---|---|
| For planting only | 87 | 82.85 |
| For planting and sale | 18 | 17.14 |
| Total | 105 | 100.00 |

## Traditional Seed Potato Storage Methods

The seed potato storage method which was widely used among the farmers in this area was keeping seed potatoes in old potato crates (capacity of 40-50 kg of seeds) in a dark place in the house. These old potato crates were slated wooden boxes in which potato seeds were imported from other countries and were issued to farmers when they purchased seeds from the government farms. These boxes can be reused for a longer time to transport seeds from the field, for seed storage and transport seeds back to the field during the planting time without causing much damage to seeds. More than 86 percent of the farmers revealed that one of the main reasons which facilitated the use of old potato crates

for seed storage was their free availability. Another reason was these boxes can be fit into any corner of the house and piled without causing much inconvenience in the household activities.

But after 1979 the government started issuing potato seeds without boxes due to various reasons. This directly affected the storage facility of the farmers and they had to look for alternative methods of seed storage. The difficulties which the farmers experienced might have been a reason why they got interested in DLS.

Inspection of seeds in boxes was not routine. The majority of the farmers (85%) revealed that after sprouting, storage losses were very high and they produced long weak sprouts after one or two months.

Table 9 shows the quantity of potatoes and storage methods used. It was observed that old potato crates were used to store small quantities as well as large quantities and it was the most preferred method (85%).

The next method used mostly was spreading seeds on the floor in a dark place in the house (41.9%). In this storage method, seeds were spread on the cemented or mud floors in 6-8 inch layers. Sometimes, farmers cover the seeds with gunnysack to enhance sprouting. It was observed that some farmers made use of this facility as a temporary storage. They transferred these seeds to old potato crates after sprouting. Storage losses in this method were mainly due to rotting and rat damage in this method. Sorting of seeds was very seldom done.

Storage of seeds in the attic was observed among 30 (28.6%) farmers. Attic is a place where they store other items such as farm tools, utensils and seed materials such as onion, garlic, beans and pumpkin. Potato seeds were spread on the wooden floor of the attic and often subjected to high temperature during the daytime and cool temperature during the night time. Losses were mainly due to shriveling of seeds, rat damage and tuber moth damage. However, only four farmers preferred this method as a good storage method.

Another storage method used by farmers was keeping seeds spread under the beds. Farmers keep seeds on a thicker pile sometimes covered with gunny sacks. The 23 farmers who used this method expressed several beliefs and social implications involved in seed potato storage. Some farmers felt that seeds should not be exposed to outsiders in order to prevent the evil eye of others. Some farmers said that seeds were more secured and keeping them at very close proximity make them happy. Some farmers felt that the space available under the bed was ideal for seed storage.

Table 9. Traditional potato seed storage methods, quantity of seeds and preference of storage method before DLS adoption (N=105).

| VARIABLE | STORED QUANTITY (50 kg) 4 | 5-9 | 10-15 | 16 | NUMBER OF FARMERS | PERCENT |
|---|---|---|---|---|---|---|
| A. Storage Method and Quantity | | | | | | |
| Old potato crates in dark | 13 | 26 | 46 | 15 | 100 | 95.23 |
| Spread on floor in dark | 16 | 18 | 9 | 1 | 47 | 41.90 |
| On the attic | 8 | 16 | 3 | 3 | 30 | 28.57 |
| Under beds | 13 | 9 | 1 | - | 23 | 21.90 |
| B. Preference of storage methods | | | | | | |
| Old potato crate in dark | | | | | 85 | 80.95 |
| Spreading on floor in dark | | | | | 5 | 4.76 |
| On the attic | | | | | 4 | 3.80 |
| Under beds | | | | | 11 | 10.40 |
| C. Combination of methods used for seed storage | | | | | | |
| Old potato crates + spreading on floor | | | | | 29 | 27.61 |
| Old potato crates + on the attic | | | | | 27 | 25.71 |
| Old potato crates + under beds | | | | | 22 | 20.95 |
| Old potato crates + spread on floor + on the attic | | | | | 9 | 8.57 |
| Old potato crates + on the attic + under beds | | | | | 11 | 10.47 |

Obviously when seeds were treated with chemicals to prevent insect pest attack, there was a great possibility of contamination of hazardous chemicals. On the other hand, when tubers started rotting it caused a very uncomfortable atmosphere in the living area. However, most of the farmers kept less than 400 kg of seed potato in this kind of storage.

It was observed that farmers never use a single storage method. Hence, they resorted to a combination of storage methods, perhaps due to unavailability of old potato crates, lack of space in the house or to avoid risk involved in keeping seeds in a single method. It was found that more than 27 percent of the seed losses occurred in traditional potato storage methods.

Looking at the different traditional storage methods, it was obvious that farmers would like to store their seeds in a secured place within their house. It was also apparent that they hardly consider the need for caring the seeds during the storage period and this aspect had been completely neglected. Losses might have been considered a natural phenomenon in seed storage.

## Problems Associated with Traditional Potato Seed Storage Methods

There are 12 most conspicuous storage problems associated with traditional potato seed storage methods that were identified (Appendix Table B). These problems were categorized into four broad areas, namely: problems associated with pest and diseases, problems associated with quality of seeds, field performances of seeds and problems associated with household environment.

Table 10 presents the problems associated with traditional potato seed storage methods. The majority of the farmers (65.7%) were faced with "highly severe" problems in storage while only 5 percent farmers seemed to have "low severe" problems.

Farmers indicated losses due to rotting, weak sprout growth, inability to store for more than six months and tuber moth damage as severe problems in the traditional storage. The severity indexes for the above problems were 0.87, 0.78, 0.70 and 0.69, respectively. There were seven moderately severe problems and only one was considered a least severe problem.

Farmers faced quite a number of problems throughout the storage period and these problems were in association with all the traditional storage methods. Actual losses occurred during the storage period and were beyond the assessment of the farmers especially that they failed to realize the magnitude of the overall deterioration of the seed quality. Tracing the individual factor that contributed to the overall seed quality deterioration was not possible as the storage problems were occurring simultaneously. For instance, difficulties in storage management

Table 10. Difficulties encountered with traditional storage methods and their severity indexes and level of severity (N=105).

| VARIABLE | SEVERITY INDEX | LEVEL OF SEVERITY |
|---|---|---|
| A. Difficulty encountered | | |
| Ability to keep more than 6 months in storage | 0.70 | Highly severe |
| Weak sprout growth | 0.78 | Highly severe |
| Tuber moth damage | 0.69 | Highly severe |
| Losses due to rotting | 0.87 | Highly severe |
| Losses due to rat damage | 0.39 | Moderately severe |
| Physiologically old seed | 0.40 | Moderately severe |
| Management and inspection of storage | 0.54 | Moderately severe |
| Time and labour involvement for storing rotten tubers | 0.49 | Moderately severe |
| Uncomfortable environment in the house | 0.43 | Moderately severe |
| Poor seed quality | 0.37 | Moderately severe |
| Poor emergence of seeds | 0.37 | Moderately severe |
| Low yields | 0.20 | Least severe |

B. Distribution of farmers according to level of severity of storage problems

| LEVEL OF SEVERITY | FARMERS Number | Percent |
|---|---|---|
| Highly severe | 69 | 65.00 |
| Moderately severe | 31 | 30.24 |
| Least severe | 5 | 4.76 |
| Total | 105 | 100.00 |

and lack of regular inspection aggravated the rotting of seeds. Poor sprout growth led to poor emergence in the field resulting to a very low yield.

## Storage Practices Before and After Adoption of DLS

The storage practices used by farmers before the adoption of DLS were limited to four. Selection of seeds before storage in order to remove spoiled tubers, was carried out by 85 percent of farmers before the adoption of DLS. Farmers were aware that unsorted seeds would result to rapid losses in storage as compared to sorted seeds. Table 11 summarizes the storage practices carried out by farmers before and after the adoption of DLS.

It shows that after the adoption of DLS the number of farmers adopting storage practices increased together with the practices adopted by farmers. Almost 60 percent of the farmers adopted the eight different practices after the adoption of DLS. Accordingly, the adoption of DLS also changed the other associated storage practices as prerequisite to its successful utilization.

In the light of the above findings, there seemed to have a growing concern among farmers about the recognition of the seed as an important input which need careful management during the storage phase. Furthermore, there had been a shift in family labor involvement in storage activities after adopting several additional storage practices.

## Potato Seed Sources and Utilization Before and After Adoption of DLS

There were three major seed sources from which farmers purchased their potato seeds. Table 12 shows the seed sources and utilization before and after the adoption of DLS.

Among the seed sources, government farms were the most commonly mentioned source from which farmers purchased seeds. There was no significant change in the number of farmers who purchased seeds from this source before and after the adoption of DLS for both Maha and Yala seasons. However, there was a decline in quantity of seed purchased from this source after the adoption of DLS. Table 13 shows the source, quantity of seeds and utilization of seeds after the adoption of DLS.

It appeared that there was a dramatic change in the use of their own produced seeds. In Maha season, there were only 32 (30%) farmers who used their own seeds for planting and the quantity used was less than 200 kg. But after the adoption of DLS, the number of farmers who used own seeds for planting was increased to 103 (98%) and the average quantity of seeds used was

Table 11. Seed storage practices of farmers before and after the adoption of DLS (N=105).

| STORAGE PRACTICE | BEFORE ADOPTION | | AFTER ADOPTION | |
|---|---|---|---|---|
| | No. | Percent | No. | Percent |
| Seed seletion before storage | 90 | 85.71 | 105 | 100.00 |
| Curing seeds | 64 | 60.95 | 87 | 82.85 |
| Grading of tubers before storage | 47 | 44.76 | 91 | 86.66 |
| Seed treatment before storage | 40 | 38.09 | 86 | 81.90 |
| Seed stored on racks as layers | - | - | 105 | 100.00 |
| Regular scrutinizing of potato in the storage | - | - | 61 | 58.09 |
| Prompt pest and disease control in the storage | - | - | 63 | 60.00 |
| Use of well sprouted seeds for planting | - | - | 90 | 85.71 |

Table 12. Sources of seeds, quantity, price and utilization of seeds in Maha and Yala seasons before the adoption of DLS (N=105).

| SEED SOURCE | AVERAGE PRICE Rs./50 kg | STORED QUANTITY (50 kg) 16 | 15-10 | 9-5 | 4 | TOTAL NUMBER OF FARMERS N | % |
|---|---|---|---|---|---|---|---|
| MAHA SEASON | | | | | | | |
| Own seeds | 375.80 | - | - | - | 32 | 32 | 30.48 |
| Government farms | 620.40 | 8 | 20 | 38 | 86 | 102 | 97.40 |
| Farmers or dealers | 920.30 | - | - | 3 | 16 | 19 | 8.09 |
| YALA SEASON | | | | | | | |
| Own seeds | 412.18 | 33 | 43 | 22 | 2 | 100 | 95.23 |
| Government farms | 770.30 | 1 | 2 | 1 | 3 | 7 | 6.66 |
| Farmers or dealers | 990.80 | - | 4 | 2 | 18 | 24 | 22.85 |

Table 13. Seed sources, quantity of seed stored, price and utilization in Maha and Yala seasons after adoption of DLS (N=105).

| SEASON/SOURCE | AVERAGE PRICE 50 kg/Rs | NUMBER OF FARMERS Stored Quantity (50 kg) | | | | | | UTILIZATION | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 16 | 15-10 | 9-5 | 4 | N | % | Plant | Sale | Both |
| Maha Season | | | | | | | | | | |
| Own seeds | 498.00 | 8 | 6 | 83 | 8 | 103 | 98.09 | 103 | 20 | 20 |
| Government farms | 910.00 | 5 | 9 | 37 | 53 | 104 | 99.04 | 96 | 8 | 8 |
| Farmers or dealers | 1004.00 | - | - | 8 | 10 | 18 | 17.14 | 18 | - | - |
| Yala Season | | | | | | | | | | |
| Own seeds | 480.00 | 62 | 29 | 14 | - | 105 | 100 | 105 | 33 | 33 |
| Government farms | 910.00 | - | - | 7 | 3 | 10 | 9.52 | 6 | 4 | - |
| Farmers or dealers | 1156.00 | 3 | 2 | 11 | 10 | 26 | 24.76 | 26 | - | - |

increased to 150 kg. During the Yala season there were only 33 farmers who used more than 800 kg of own seeds for their planting. It increased up to 62 farmers after the adoption of DLS.

With regard to the third source of seeds there had been a slight increase in the quantity purchased from farmers or dealers in Yala season after the adoption of DLS.

These findings revealed that there had been a greater change in seed utilization particularly the use of own produced seeds as a consequence of DLS adoption. Despite the fact that seed availability was somewhat greater than before the adoption of DLS there were farmers who still purchased some quantity of seeds from government sources. Perhaps some of them still consider the government seeds are better than their own seeds and they could improve the seed stock using government seeds.

In analyzing the cost of seeds from different sources, it turned out that farmer-produced seeds were approximately 50 percent cheaper than government seeds and nearly 100 percent cheaper than seeds purchased from dealers or farmers. This trend was observed for both seasons before and after adoption of DLS. However, there were significant price differences between and among seed sources before and after the adoption of DLS.

## Quality of Seeds Purchased from Different Seed Sources

Table 14 shows that more than 75 percent of the farmers preferred to buy just sprouted seeds at the time of planting but only 30 percent of farmers purchased well sprouted seeds. With regard to government seeds, farmers (85%) were compelled to buy what were available at the time of purchase hence there was no choice in buying preferred seeds from this source.

None of the farmers were interested in purchasing freshly harvested potato which could be obtained at relatively lower price and stored in DLS for subsequent use.

## Problems Encountered in Using Seeds from Outside Sources

The problems associated with external seed sources were related to governmet seed source. These problems are summarized in Table 15. It was also evident that almost all of the problems were connected with distribution system and quality of the seeds. More than 63 percent of the farmers reported that graft and corruption existed in potato seed distribution system and it had been perpetuated in the last decade. However, farmers had faith on the quality of seeds and the reasonable price structure of seeds from the government seed source.

Table 14. Type of seeds purchased from seed sources before adoption of DLS (N=105).

| SEED TYPE | SOURCE Government Seeds | Farmers' Seeds | Dealers' Seeds | TOTAL | PERCENT |
|---|---|---|---|---|---|
| Well sprouted seeds with long sprouts | | 2 | 20 | 32 | 30.47 |
| Unsprouted seeds | | 3 | - | 3 | 2.85 |
| Freshly/harvested seeds | | 4 | 4 | 8 | 7.61 |
| Just sprouted seeds | | 45 | 35 | 80 | 76.19 |
| Well sprouted seeds with sturdy sprouts | | - | - | - | - |
| What is available at purchase time irrespective of the condition | 90 | - | - | 90 | 85.71 |

Table 15. Problems encountered by using seeds from outside sources (N=105).

| PROBLEM | SOURCE | | | | | |
|---|---|---|---|---|---|---|
| | Government Farms | | Farmers | | Dealers | |
| | No. | Percent | No. | Percent | No. | Percent |
| 1. Seeds not available at proper time of planting | 87 | 82.85 | - | - | - | - |
| 2. Restricted allocation of seeds | 95 | 90.47 | - | - | - | - |
| 3. Long official procedures in purchasing the seeds | 82 | 78.09 | - | - | - | - |
| 4. Graft and corruption in seed issues | 67 | 63.80 | - | - | - | - |
| 5. Low quality of seeds | 6 | 5.71 | 45 | 42.85 | 22 | 20.95 |
| 6. High price of seeds | 4 | 3.20 | 32 | 30.47 | 22 | 68.57 |
| 7. Unreliability of the source | 10 | 9.52 | 18 | 17.14 | 14 | 13.30 |

With regard to other seed source, seeds from farmers were considered as somewhat low in quality (42%) and high priced (30%). More than 68 percent of the farmers considered the seeds from dealers comparatively expensive.

## Simultaneous Use of Traditional Seed Storage Methods After Adoption of DLS

It was expected that adoption of DLS would gradually replace the traditional storage system. However, this was not so in the study area even after four years of DLS adoption. It was found that 85 percent of the DLS farmer adopters still use the old potato crates for storing seeds (Table 16).

Simultaneous use of traditional storage practices suggested that these farmer adopters were not still fully convinced of the DLS. Furthermore, it indicated that while DLS technology was still undergoing farmers' evaluation in their own situation, the use of traditional storage practices would provide them assurance of the seed supply. One reason behind this practice was lack of space in the DLS as disclosed by 23 percent of the farmer adopters.

Another reason indicated by the farmers was that they still possess old potato crates and wanted to make use of them. This was disclosed by 18 farmers.

Another 15 percent of the farmers used traditional storage methods to enhance early sprouting of seeds for early planting just on the onset of the season. Early planting of potato is preferred by the farmers especially in the Yala season to get a better price for the produce if they harvest ahead from the rest.

Some farmers who utilized DLS for storage of seed both for own planting and for sale used traditional methods as a temporary measure but they transfer the sprouted seeds from the traditional method to DLS storage.

This study suggested that farmers do not get rid of old storage practices just because they adopted the DLS. Instead they tried to integrate DLS into the present storage methods and made use of the traditional methods to supplement and/or complement the DLS just to have an assurance that they had the supply of seeds just in case the new method fails.

## Family Members' Involvement in Storage Practices

Family members provided the human resource especially in small-scale farming operations in the farms in this area. It was found that all the able members of the family participated in storage activities both before and after adoption of DLS. Table

Table 16. Traditional potato seed storage methods and reasons for using them even after the adoption of DLS (N=105).

| VARIABLE | FARMERS | |
|---|---|---|
| | Number | Percent |
| A. Storage Methods | | |
| Old potato crates | 87 | 35.23 |
| Spreading on floor | 10 | 9.52 |
| On the attic | 4 | 3.80 |
| Heaps on the floor | 3 | 2.85 |
| B. Reasons for use of traditional methods | | |
| Not enough space in the DLS | 25 | 23.30 |
| Space available in the house | 17 | 16.19 |
| To promote early sprouting | 16 | 15.23 |
| As a temporary measure | 17 | 16.19 |
| To keep seeds until sprouting and later transfer to DLS | 12 | 11.42 |

17 presents the family members' participation in storage activities.

Table 17. Family members' involvement in storage practices before and after adoption of DLS (N=105).

| FAMILY MEMBER | BEFORE DLS No. | BEFORE DLS Percent | AFTER DLS No. | AFTER DLS Percent |
|---|---|---|---|---|
| All members | 105 | 100.00 | 105 | 100.00 |
| Wife | 90 | 85.71 | 98 | 93.33 |
| Children | 74 | 70.47 | 84 | 80.00 |
| Other relatives | 88 | 83.80 | 79 | 75.23 |
| Wife + children + other relatives | 60 | 37.14 | 69 | 65.71 |
| Wife and children | 11 | 10.47 | 11 | 10.47 |
| Wife and others | 11 | 10.47 | 17 | 16.19 |

It was apparent that storage practices were carried out usually by family members. Although there was no assigned storage practices to individual members of the family, the role played by the housewife in the storage practices was predominant. The involvement of the other family members was in the transport of seed from the field, sorting of tubers, putting the seeds into the storage, seed treatment, regular inspection, and seed selection. These activities needed the cooperation of all members. Older children were also important part of the family labour force.

Table 18 presents the frequency of seed sorting in stored seed potatoes for planting. Sorting seeds in the storage was considered a family affair. It involved taking out the seeds from the storage place, sorting rotten tubers and putting them back into storage. The majority of family members were of the opinion that the most cumbersome storage activity was tuber sorting. This was revealed by 82 percent of the family units (Table 19).

Frequency of sorting seeds was done more at the later stage of storage. Fifty percent of the farmers sorted seeds whenever possible and just before planting. Only 30 percent of the farmers sorted seeds once every two weeks and/or once a week. Looking at the time and labor involvement in the overall storage pratices, 80 percent of the farmers said that time and labour involvement after the adoption of DLS was less than before the adoption of DLS. However, 20 percent of the farmers viewed DLS as demanding more labour and time for storage activities. Perhaps, this might have been due to the use of other storage practices used before.

Table 18. Frequency of seed sorting in stored seed potatoes before planting (N=105).

| FREQUENCY OF SORTING | FARMERS | |
|---|---|---|
| | Number | Percent |
| Once a week | 13 | 12.38 |
| Once in two weeks | 19 | 18.09 |
| Once in four weeks | 27 | 25.71 |
| Whenever possible | 33 | 31.42 |
| Just before planting | 21 | 20.00 |

Table 19. Difficult and cumbersome storage activities of farmers before adoption of DLS (N=103).

| ACTIVITY | FARMERS | |
|---|---|---|
| | Number | Percent |
| Sorting of rotten tubers in the storage | 87 | 82.85 |
| Seed transport from field to storage | 13 | 12.38 |
| Pests and diseases control in the storage | 3 | 2.85 |

## Adoption Process of DLS Technology

DLS Adoption Over Time.

The time taken for initial adoption decision varied widely among the farmers and it was viewed as a sequential process rather than a differential innovativeness of individual farmers (Roger and Shoemaker, 1971).

Table 20 shows the cumulative percentage of farmers who adopted the DLS from the time of their initial exposure to the time of their final adoption of the practice.

The average time taken for initial adoption decision was 17.85 months or about one and one-half years, although the range was 2-51 months and the standard deviation was 12.34. It could be observed that 43 percent of the farmers adopted DLS during the first year of introduction. At the end of the second year, there were 77 farmers (73%) who adopted DLS. However, there were 11 (10%) farmers who took more than 36 months to adopt DLS. Although the adoption rate followed the customary sigmoid curve, this trend might have been manipulated and influenced by farmer's external agro-socioeconomic environment to a larger extent. Rapid early adoption behavior of farmers might have been largely influenced by the hierarchical attention given by social technologists through extension delivery system first to resource-rich farmers in disseminating DLS with a diminishing effort extended later to resource-poor tail enders.

It was obvious that DLS technology and its performance under farmer's condition at the early stage were foreign both to the farmers as well as those who were engaged in dissemination. However, it was observed that early adoption behavior of the farmers was not due to innovativeness of farmers but might have been due to early opportunities to exposure to the technology, easy access to resources and the farmers' pressing needs for such integration of technologies to ease their problems within their farming systems. It was also observed that early adopters modified their DLS storage structures several times as compared to late users of DLS. Although early adopters took adoption decision earlier, actual adoption of DLS was partial rather than total. They possibly had inadequate understanding about the DLS performance under their situation, required capacity of the storage, accompanied storage practices and seed utilization.

In contrast, late users of DLS were more confident and aware about the performance of DLS under their own setting, utilization of seeds from DLS, and the construction and management of DLS within their means. These findings suggested that late users of DLS had an added advantage over early users in evaluating DLS over time without taxing their own resources and had an opportunity to evolve their own modifications. This process needed time for careful evaluation, adjustment and readjustment. Early

researchers often viewed the late adopters as "laggards" in technology adoption process without giving due weight to these aspects of farmer adoption behavior. Therefore, it may be erroneous to conclude and classify late adopters as well as non-adopters as laggards since adoption process needs differential time periods to assess and adopt certain technologies under heterogeneous farmers conditions. On the contrary the offered technology may not be suitable to the farmers' agro-socioeconomic environment. Hence, farmers' rational behavior in this context may be inappropriate to perceive in terms of laggardness. It may rather be indirectly stated that the technology generation institutions and persons involved failed to recognize in time the farmers' actual needs and conditions. If they were known easily enough, the changes and modifications should have been incorporated in the process of developing the acceptable technology.

The above findings suggested that there were three broad adoption processes among DLS adopters. They are: formal adoption, iterative adoption, and galloping adoption processes (Fig. 3).

## Formal Adoption Process

Initially, there was a diffused awareness among the farmers with regard to the DLS technology and its adaptability to their setting as was created and developed by the extension agents. Given the inevitable uncertainties, farmers evaluated DLS in terms of its application to their farming system. This included seed utilization, expected changes in cropping system, farmers inconvenience over traditional methods and DLS adaption according to their resources and needs. After the trial stage the decision to adopt DLS was largely influenced by extension. Final adoption was partial rather than total. Some farmers used only racks for storing seed potatoes omitting aspects of diffused light and ventilation. Some farmers modified the existing storage while some farmers constructed separate buildings for this purpose. The majority of the early adopters (below average month of 17.34) were in trial stage for a long time.

There had been several modifications to the storage despite earliness of adoption. In this process, it appeared that five stages of adoption process explained by Roger and Shoemaker (1980) had taken place in a sequential manner except the evaluation stage which perpetuated throughout the process. Thirty-two farmers had this process.

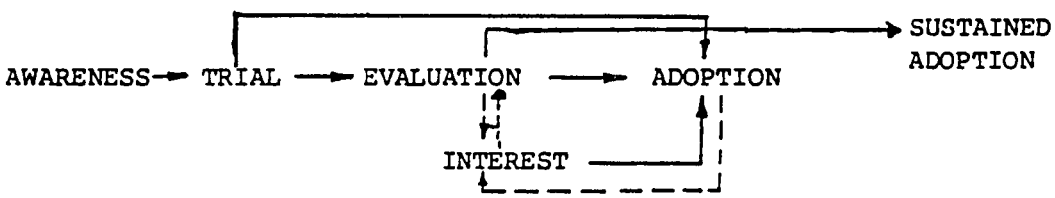
## Iterative Adoption Process

In the second classification of the adoption process, the sequential steps proposed by Rogers and Shoemaker (1980) were not strictly followed. Once the farmers became aware of the DLS it

1. Formal Adoption Process

AWARENESS → INTEREST → EVALUATION → TRIAL → ADOPTION

2. Iterative Adoption Process




3. Galloping Adoption Process

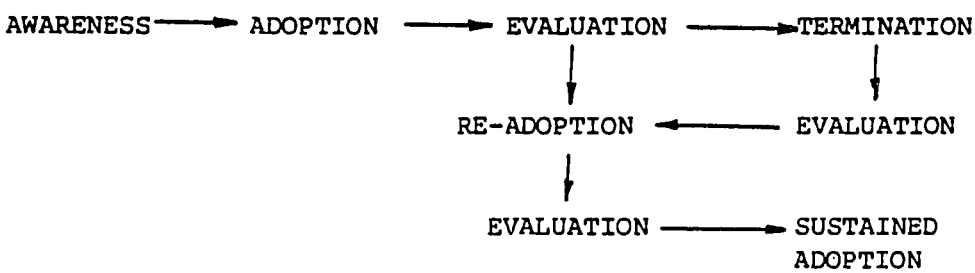



Figure 3. Adoption processes of DLS during 1978-1983.

was followed by repeated evaluation periods. Alternative courses of action were taken from time to time based on their perceptions and observations of other farmers' DLS before making a final decision to adopt. This was enhanced by the several extension programs and training programs held for farmers as well as by the extension agents enable them to interact each other and facilitated dialogue between them.

Seemingly, there was no evidence of trial stage in this adoption process. Farmers adopted DLS without any trial. This was reported by 46 farmers and their storage facilities were somewhat improved than the storage made by the early adopters and were subjected to repeated modifications. Hence, the repeated evaluation and adaptations activities during this period may be referred to as iterative adoption process.

Galloping Adoption Process

In the third adoption process as observed in this study, farmers adopted DLS after awareness without proper evaluation or trial. They came to realize the benefits of the technology after the adoption of DLS. After using DLS for few seasons farmers terminated its use but started utilizing it again in subsequent seasons. In this process, evaluation of technology and its trial was based on other farmers' storage experience on DLS rather than their own. But it was observed that subsequent adoption of DLS was complete and storage structure were mostly permanent by using durable materials in the construction. The majority of the farmers who followed this adoption process were late adopters.

Interestingly, there were 14 farmers who adopted DLS initially not for seed storage purpose but to obtain extra imported seed crates which were given by extension agents as an incentive to adopter farmers for producing more seeds. However, these farmers modified some portion of their storage facility and showed it to the extension agents for their approval and get extra seed crates. Subsequently, they abandoned the DLS and not used it at all for seed storage.

Four farmers adopted DLS abruptly in order to get bank loans which was launched in 1983 without even realizing how to use it for seed storage. Only two of these farmers reported that they were still using the storage facility while the other two abandoned the DLS storage utilization after obtaining the bank loans.

The sequential decision taken by farmers at different stages of the adoption process might have been influenced substantially by different sources of information, their resources, constraints and their real needs at the adoption time. These different adoption processes suggested that farmers' decision to adopt new technologies do not necessarily follow sequential steps but an ad-

mixture of these steps and processes which interacted simultaneously.

## Initial Exposure to DLS and Adoption

As discussed earlier, the time taken by individual farmers to adopt DLS varied from 2-51 months. However, the farmers' pattern of exposure to DLS and pattern of adoption had a significant relationship. Figure 4 shows the cumulative number of farmers exposed to DLS and farmers' subsequent adoption patterns. It also shows the number of farmers exposed to DLS each year and corresponding number of adopters for that particular year. Both curves behaved in similar fashion.

The curve shows that in 1982 there was a slow down in the number of farmers exposed to DLS. But cumulative effect of exposure during the previous years resulted to drastic increase of adopters in 1982. This suggested that continuous exposure to DLS technology followed a continuous adoption behavior among the farmers with a given set of resource endowment. Furthermore, this pattern did not imply that mere exposure to DLS would simply lead to subsequent adoptions after sometime. Perhaps the rate of exposure and rate of adoption patterns are important in determining some properties of the adoption process like time, sustainability and strategies used to expose the technology. Table 20 shows the number of farmers exposed to and who adopted DLS over time. The time gap for exposure to adoption was gradually diminished in the subsequent years. This could be attributed to the "demonstration effect" and availability of more information on its performance under the local conditions.

## Areas of Information Sought in DLS Adoption Process

One type of consideration underlying the spatial and temporal differences in adoption was the potential adoption information needs and access to relevant information. This aspect had been examined for the predominant information sources namely extension agents and farmers.

The majority of the farmer adopters obtained information on practical utilization of DLS both from extension agents and farmers (82%, 70%, respectively). Similarly, 78 percent of the adopters revealed that they got information on construction aspects of DLS specially in structural modification and adaptation stage from extension agents. However, only 20 percent of farmers got information from the early adopters in the village. Table 21 shows the information provided by the farmers and extension agents. More than 75 percent of the farmer adopters were influenced by extension agents on the agro-socioeconomic benefits of the DLS.

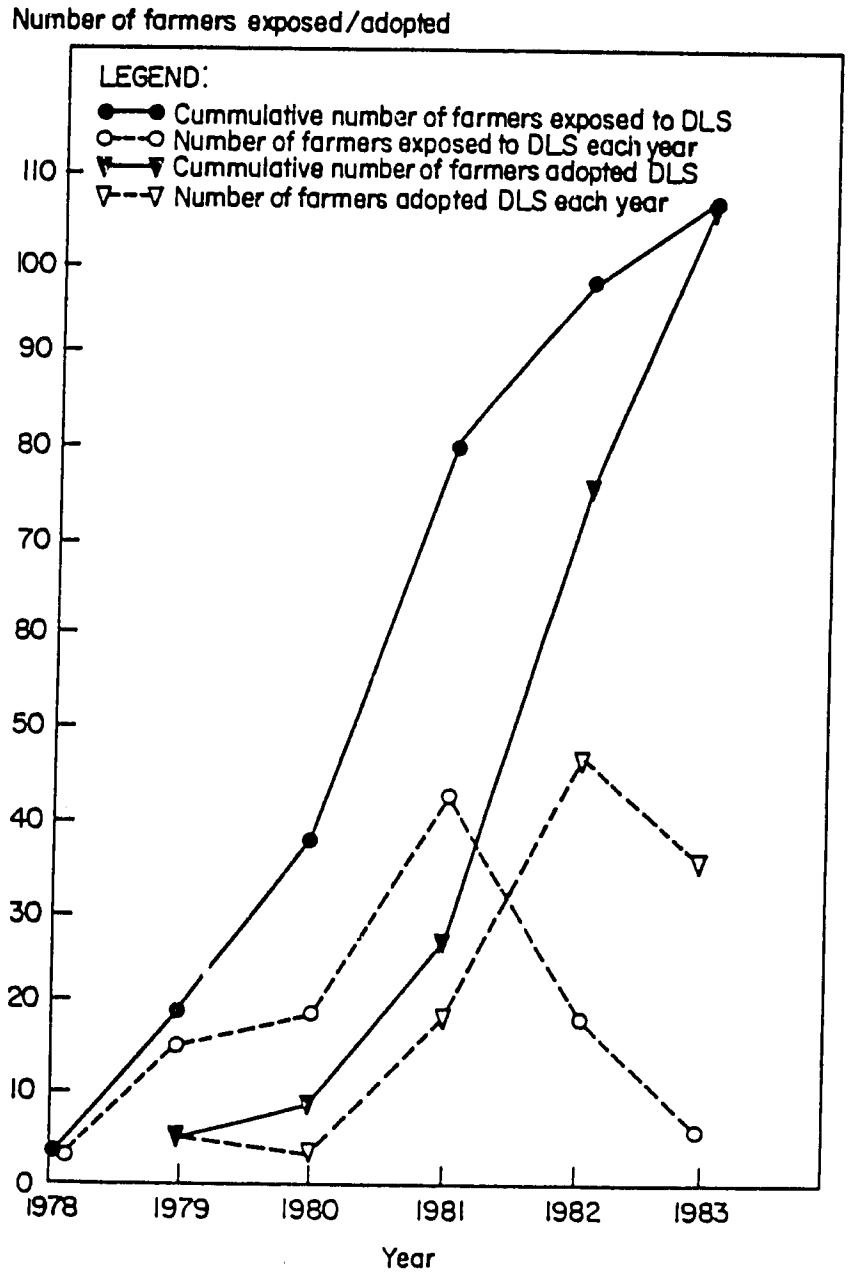



Fig. 4. Logistic curve showing trends in the number of farmers who were exposed and who adopted DLS during 1978 to 1983.

Table 20. Distribution of farmers according to the time of adoption after exposure to DLS technology (N=105).

| TIME OF ADOPTION (Months) | FARMERS No. | FARMERS Percent | CUMULATIVE No. | CUMULATIVE Percent |
|---|---|---|---|---|
| 2 - 6 | 20 | 19.05 | 20 | 19.05 |
| 7 - 12 | 26 | 24.75 | 46 | 63.81 |
| 13 - 18 | 16 | 15.24 | 62 | 59.05 |
| 19 - 24 | 15 | 14.29 | 77 | 73.34 |
| 25 - 30 | 14 | 13.33 | 91 | 86.67 |
| 31 - 36 | 3 | 2.85 | 94 | 89.52 |
| 37 - 42 | 7 | 6.68 | 101 | 96.20 |
| 43 - 48 | 2 | 1.90 | 103 | 98.10 |
| 49 - 54 | 2 | 1.90 | 105 | 100.00 |

Table 21. Information provided by farmers and extension agents about the DLS. (N=105).

| AREA OF INFORMATION | FARMERS No. | FARMERS Percent | EXTENSION AGENTS No. | EXTENSION AGENTS Percent |
|---|---|---|---|---|
| Information on economic benefits of DLS | 44 | 41.90 | 79 | 75.23 |
| Information on agronomic benefits of DLS | 56 | 53.33 | 80 | 76.19 |
| Information on construction aspect of DLS | 21 | 20.00 | 82 | 78.09 |
| Information on practical utilization of DLS | 74 | 70.47 | 87 | 82.25 |

It was revealed that most of these information were sought and provided during the evaluation stage of the adoption process followed by trial stage and hardly in the adoption stage. Results indicated that prior to adoption of DLS, farmers needed a wide range of information on various aspects of the DLS. Thus, extension agents should provide or disseminate adequate knowledge of the technology as well as its performance under the farmers' conditions after the awareness stage or introduction of the technology.

## Persons Who Influenced Farmers in the Various Stages of Adoption

Among the persons who influenced the farmers in the different stages of the adoption process, the extension agents played a vital role. In the awareness stage, 98 farmers came to know about DLS through the extension agents.

Seventy-two farmers said that they were influenced by the extension agents in the evaluation stage. At the tail-end of the adoption process the diminishing role of extension agents was evident; only 32 farmers were influenced by the extension agents at the adoption decision stage. On the contrary a reversed trend was observed with regard to other farmers' influence. The influence of other farmers was relatively higher at the trial and adoption stages.

Village leaders and other government officials influenced the farmers at the last two stages of the adoption process. Only four persons said that they were influenced by the research personnel at trial and adoption stages. Influence of varied elements in various stages of the adoption process had different effects on farmers' evaluation and final adoption of DLS. An unconspicuous picture of the role played by each element masked the understanding about the vital stages of adoption in which each

Table 22. Distribution of farmers in the adoption process and persons who influenced them and modifications during the process (N=105).

| PERSON INFLUENCING AND MODIFICATION | STAGE OF ADOPTION PROCESS | | | |
|---|---|---|---|---|
| | Awareness | Evaluation | Trial | Adoption |
| A. Persons who influenced the adoption | | | | |
| Extension agents | 98 | 72 | 48 | 32 |
| Farmers | 8 | 18 | 37 | 44 |
| Research personnel | 2 | - | 4 | 4 |
| Other government officers | - | - | 17 | 13 |
| Village leaders | - | 12 | 17 | 12 |
| B. Modifications made in various stages of adoption | | | | |
| Management practices | 36 | 12 | 74 | 94 |
| Structural modifications | - | - | 96 | 98 |
| Location of seed storage | - | - | 30 | 34 |
| Utilization of seeds | 6 | 16 | 64 | 88 |

discipline could influence effectively or hasten the adoption process.

Section B of Table 22 shows that most of the storage modifications were at the later stages of the adoption process. However, management practices of the storage were modified and adopted even at the awareness and evaluation stages. These information suggested that evaluation and trial stages were the most critical stages where influence of change agents should really be made. Moreover, it also suggested that re-orientation of extension activities at various stages would yield conspicuous effects on the total adoption process.

## Incentives and Encouragement that Influenced Farmers During the Adoption Process

It seemed that during the adoption process potential adopters particularly in the early stages of adoption had received preferential treatment both from fellow farmers and government officials in matters pertaining to potato production such as access to credit, access to government seed sources, and more extension contacts. More than 89 percent of the farmers received prefential treatment from the government officials while 45 percent received preferential treatment from the fellow farmers. Moreover, majority of the farmers said that they were accorded with a relatively high social position in the community after their adoption of DLS. Table 23 presents the incentives and encouragements they received from fellow farmers and others.

It was also indicated that farmers were subjected to social degradation such as an evil eye or ill-will from other farmers of the village after adoption of DLS (55%). The existence of this kind of treatment among some farmers as a social force to hamper the adoption process was found negligible. Farmers believed that such evils were part and parcel of the farming community.

Table 23. Incentives, encouragement and social recognition accrued to adopters of DLS. (N=105)

| ITEM | FARMERS | | OTHERS | |
|---|---|---|---|---|
| | No. | Percent | No. | Percent |
| Preferential treatment | 79 | 75.23 | 94 | 89.52 |
| Provision of material for construction of DLS and potato production | 22 | 20.95 | 81 | 77.14 |
| Relatively higher position in the community | 95 | 90.43 | 83 | 79.04 |
| Positive comments from others regarding the DLS | 37 | 35.23 | 35 | 33.33 |
| Evil eye or ill-will of others | 58 | 55.23 | - | - |

## Factors Influencing the Interest of Farmers in Using DLS

Quality seeds. One of the factors that motivated and aroused interest among the farmer adopters was the ability to produce good quality seeds with strong and vigorous sprouts. This implied that although they had been using long sprouted seeds their intention to use good quality seed was pronounced. Further, they perceived that using potato seeds stored in DLS would result in higher yields. This view was contradictory to as far as their storage difficulties were concerned.

Separate storage facility. Another factor that aroused the interest of the farmers was the need for a separate place for seed storage. This was reported by 77 percent of the farmers. Others were less storage losses and convenience in storage management.

These are actually practical reasons/factors that any prospective adopter would look into. Table B in the Appendix shows the other factors that influenced the farmer adopters.

## Characteristics of the Technology

The extent to which a certain technology is adopted and utilized in a farming system are greatly influenced by the specific characteristics of the particular technology, and suitability of the technology to a given set of resources. Furthermore, a plausible explanation for failure to diffuse new technologies thru the diverse agro-socioeconomic environment may be attributed to location-specificity of the technology (Ashby, 1982).

In this context, the characteristics of DLS were viewed in terms of three criteria, namely: economic, social and agronomic aspects.

With regard to economic characteristics associated with DLS as much as 87 percent of the farmers perceived that construction cost of DLS was affordable and it was not a limiting factor for adoption. The average construction cost for one ton capacity storage facility was Rs. 3200.00. The majority of the farmers (87%) initially made modification to the existing storage facilities rather than constructing new storage facilities. This would have been the reason for low-cost involvement. Among the farmers who constructed new storage facilties, 13 percent spent more than Rs. 4300.00 for a one-ton capacity storage structure. However, 37 percent of non-adopter farmers revealed that lack of funds for construction of DLS was a stringent limitation.

Another characteristic considered was labour saving ability of DLS over the traditional storage method. It was expected that DLS would save labour in storage. The figures on Table 24 revealed that it was not so.

It was evident that convenience in management and utilization of DLS as compared to traditional storage method were very high (94%).

Section B of Table 24 presents the other perceived characteristics of DLS by farmers. The majority of the farmers perceived that DLS was a simple technology, they could easily understand the underlying priciples of the technology and make use of them within their capabilities, skills and resources.

Table 24. Characteristics of the DLS technology as perceived by adopters (N=105).

| CHARACTERISTIC | FARMERS' PERCEPTION | | | | |
|---|---|---|---|---|---|
| | High | | Low | | Total |
| | No. | Percent | No. | Percent | |
| A. Suitability of DLS | | | | | |
| Construction cost | 13 | 12.3 | 92 | 87.61 | 105 |
| Labour saving | 57 | 54.28 | 48 | 45.71 | 105 |
| Convenience | 99 | 94.28 | 6 | 5.71 | 105 |
| B. Other characterics of DLS | | Number | | Percent | |
| Feasibility of small-scale trial | | 103 | | 98.09 | |
| Simple technology | | 102 | | 97.14 | |
| Technology fit into present cropping system | | 94 | | 89.52 | |

The most important agronomic characteristic which attracted farmers (90%) was the capability of DLS to fit into their present cropping system adequately. This was not only observed in terms of resource endowment of the farmers but also in the social environment context of the farm family. However, farmers revealed that DLS was not perfectly fitted into their farming systems but it underwent certain adjustments and readjustments in order to fit it into the existing farming system. Furthermore, it also altered some aspects of the management and economic system of the farming operations. This was reflected both in the storage phase and field phase of the DLS seed utilization. Another fascinating characteristic of the DLS which was appreciated by the farmer adopters was its trialability. As many as 98 percent of the farmers viewed that feasibility of small scale trials of DLS was highly possible, irrespective of diverse agro-socioeconomic conditions of the farmers.

It was apparent in the initial stage of adoption by early adopters that some farmers tried the DLS in a small way while

others experimented adopting one or two salient features of DLS. One farmer revealed that he tried few tubers on the window sill to evaluate the effect of the diffused light on sprouted seeds and after two weeks he observed tubers greening and cessation of sprout elongation. Some farmers used the existing storage facility for experimenting about 10-15 kg of seed potatoes to be exposed to diffused light and planted separately to evaluate the performance of those seeds. Some farmers constructed a few racks using locally available material such as bamboo and round timber and evaluated the DLS technology in a small scale. Still a few farmers tried the effect of diffused light using the traditional attic.

Thus, these findings suggested that one of the most attractive features of DLS was its flexibility for adaptation and utilization under the farmer's diverse conditions.

## Relative Advantages of DLS as Perceived by DLS Farmer Adopters

These aspects had been examined from a broad agro-socioeconomic perspective. Relative advantage level was constructed to explain each component as perceived by the farmer adopters. Table 25 presents the perceived relative advantages.

With regard to relative agronomic advantages over the traditional method of seed storage, the ability to produce good quality seeds and possible long storage period were considered as highly desirable and their advantage indexes were 0.82 and 0.72, respectively. Low pest and disease incidence in the DLS storage and less risk in using their own seeds were considered advantageous (advantage index 0.36 and 0.35 respectively), as compared to the previous method.

Two of the relative economic advantages considered were reduction of cost of seeds, and increase in yield with concommitant increase in income. (Advantage indexes were 0.91 and 0.76 respectively). However, the actual contribution of DLS in the overall income increase was not possible to differentiate. The yield increase and the corresponding increase in income was not probably due to the use of DLS alone but to the other factors like variety, fertilization, etc. Farmers' capacity to sell more potato seeds to other farmers had been increased and this was claimed as an added advantage over the previous methods (Relative advantage index 0.59).

Farmers' dependency on outside seed sources has been reduced to a substantial level while ease of decision making in potato production was facilitated. In this respect relative advantage indexes were 0.83 and 0.71, respectively. All other social aspects such as more social participation, relief from the drudgery involved in seed storage, clean household environment

Table 25. Relative advantages and disadvantages of DLS as perceived by adopter farmers (N=105).

| ITEM | NUMBER OF FARMERS | | | LEVEL OF ADVANTAGE INDEX | |
|---|---|---|---|---|---|
| | Highly Advantageous | Advan-tageous | Less Advantageous | Advantage Index | Level |
| A. Technical | | | | | |
| Good quality seed production | 74 | 18 | 13 | 0.82 | Highly advantageous |
| Reduction in seed losses | 43 | 27 | 35 | 0.62 | Advantageous |
| Easy management of storage | 37 | 47 | 19 | 0.62 | Advantageous |
| Long storage period (6-8 months) | 44 | 48 | 15 | 0.72 | Highly advantageous |
| Low pest and disease incidence in storage | 12 | 29 | 49 | 0.36 | Advantageous |
| Less risk by using own seeds | 12 | 16 | 74 | 0.35 | Advantageous |
| B. Economic | | | | | |
| Reduces cost on seeds | 79 | 18 | 8 | 0.91 | Highly advantageous |
| Increased yield hence income | 81 | 24 | - | 0.76 | Highly advantageous |
| Can sell more seeds | 8 | 74 | 22 | 0.59 | Advantageous |
| Multiple use of storage | - | 6 | 5 | 0.05 | Less advantageous |
| C. Social | | | | | |
| Less dependency on seed sources | 75 | 14 | 9 | 0.83 | Highly advantageous |
| Easy for decision making on potato production | 72 | 24 | 7 | 0.77 | Highly advantageous |
| More contact with other potato farmers | 18 | 44 | 39 | 0.49 | Advantageous |
| Get away from drudgery involved in seed sorting in storage | 29 | 54 | 14 | 0.57 | Advantageous |
| Home is more cleaner and tidy | 6 | 48 | 44 | 0.42 | Advantageous |
| More cooperation among family members | 14 | 42 | 39 | 0.47 | Advantageous |
| D. Disadvantages | | | | | |
| Seeds take longer time to sprout | 52 | 10 | - | 0.61 | Disadvantageous |
| Subjects to ill will of others | 11 | 32 | - | 0.32 | Less advantageous |
| Other farmers need more assistance in seed supply | 8 | 11 | 17 | 0.14 | Less advantageous |
| Cannot use year around as a seed storage facility | 12 | 21 | 3 | 0.26 | Less advantageous |
| Security of stored seed | 64 | 20 | - | 0.83 | Highly |

| Advantage Level | Advantage Index Range | Disadvantage Level | Disadvantage Index Range |
|---|---|---|---|
| Highly advantageous | 0.67 and up | Highly disadvantageous | 0.67 and up |
| Advantageous | 0.33 - 0.66 | Disadvantageous | 0.33 - 0.66 |
| Less advantageous | 0.32 and below | Less disadvantageous | 0.32 and below |

and family members' cooperation were considered advantageous and their indexes were 0.49, 0.57, 0.42 and 0.47, respectively.

These findings suggested that the use of DLS was relatively advantageous to the adopters as compared to their traditional potato seed storage methods.

## Relative Disadvantages of DLS as Perceived by Adopters

One of the agronomic disadvantage mentioned was the delayed sprouting of seeds in DLS storage. This was particularly expressed by the farmers who planted small areas of potatoes during the Yala season, as they needed early sprouted seeds for early planting. More than 55 percent of the farmers claimed that seeds in DLS required 2-3 weeks more to initiate sprouting than the seeds in the traditional storage. Assessed disadvantage index was 0.61. This delay in sprouting may not be a disadvantage to the farmers who store seeds beyond the Yala season for the next planting.

A major disadvantage of DLS was the insecurity of stored seed potato especially when out buildings were used. Disadvantage index was 0.83. Ill-will and other farmers' expectations for assistance in seed supply were perceived as other disadvantages.

As far as economic disadvantages were concerned inability to use DLS the year around for storing seed, was expressed by 32 farmers. The disadvantage index was 0.26. These disadvantages however, did not considerably affect the acceptance of DLS as a technology which could solve the storage problems of the farmers.

## Farmers' Self-Oriented Motives in DLS Adoption

Although DLS technology was introduced to farmers in order to solve some of their seed storage problems, empirical evidence of the study suggested that most of the farmers adopted DLS technology in order to overcome certain external pressure exerted in their farms from the farming environment. Subsequently, farmers had realized the real benefits after using DLS technology in solving their storage problems. This implied that it was not only the storage problems that motivated farmers to adopt DLS but also other external imposition such as: non-availability of quality seeds, restriction of seed supply by government seed services and escalating price of imported seeds.

Table 26 shows that the majority (73%) of the farmers were motivated to adopt DLS because they encountered difficulties in purchasing seeds from outside especially from the government sources. The adopters seemed to be more concerned of expanding

Table 26. Farmers' self-oriented motives in DLS adoption (N=105).

| MOTIVATION FACTOR | NUMBER | PERCENT |
|---|---|---|
| To avoid difficulties associated with seed purchase from government sources | 77 | 73.30 |
| To have adequate quantity of seeds at the time of planting | 38 | 26.66 |
| To cultivate more lands due to the availability of stored seeds | 68 | 64.76 |
| To produce low cost seeds for both seasons | 14 | 13.33 |
| To sell more seeds | 13 | 12.38 |
| To organize the seed storage | 18 | 26.66 |
| To lessen dependency on other seed sources | 37 | 35.23 |
| Due to continuous interaction and encouragement of extension agents | 16 | 15.23 |
| Family members' enthusiasm to try the DLS in a small scale | 22 | 20.95 |

their potato crop. This motivated 65 percent of the farmers to adopt DLS. However, only 13 percent of the farmers adopted DLS to reduce the cost of seeds. Although only 12 percent of the farmers were motivated to adopt DLS in order to sell more seeds, their quantity of seed storage was considerably larger than any one of the farmer adopters. It appeared that farmers speculative economic behavior was less expressed at the early stages of adoption. This may be due to uncertainties and risks involved in trying new ventures under the local conditions.

Another important social motivation factor expressed by farmer adopters of DLS was that they could lessen the dependency on outside seed sources (35%) thus reinforcing their own socio-economic position.

Family members' enthusiasm to try DLS on a small scale (22%) was another motivation factor expressed by the farmers. This motivation factor had paramount importance in the family farms since farm family members were also involved in the decision making process in farming operations.

## Reasons for Non-Adoption of DLS

Thirty non-adopters were interviewed to find out the reasons why DLS was not adopted by them. Of the thirty farmers, 23 were aware of the DLS technology mostly through the extension agents. Most of them (18) were reluctant to adopt DLS because of the insecurity of seeds during storage. Only eight farmers said they did not adopt DLS due to lack of funds. Interestingly, 12 farmers were planning to build DLS storage during the next season.

Only four farmers totally rejected the DLS on the ground that it does not have any advantage over their traditional storage method. There were six farmers who were still evaluating the DLS technology while seven farmers said that they lack knowledge about the DLS. Appendix Table D shows the specific reasons for non-adoption of DLS by the farmers.

Seemingly, the farmer non-adopters had some confidence in the traditional storage methods. Part B of Appendix D presents some of the reasons and advantages perceived by farmers in using the traditional storage method.

Among non-adopters, 43 percent said that they had enough space in the house to store 200-250 kg of seed potatoes and they needed to keep the seeds only for 4-5 months. They plant potato only in one season. Eight farmers felt that they did not have any storage problem so as to change the traditional storage methods. Similar findings were reported by Rhoades and Booth (1981) in their study in Mantaro Valley in Peru. Some farmers stored seeds more than what they required and took it for granted that losses in storage were natural phenomenon. In this study, similar situation was reported by six farmers.

Reasons for Storage Modification

One of the salient features of DLS is the provision of diffused light on the stored potato seeds to have the tuber greening effect, to check the sprout growth and other light effects. However, this feature was not quite useful and beneficial to some of the farmers as their need was to keep seeds only for 3-4 months until the next planting season. Since they did not have adequate amount of seeds even for the Yala planting, there were hardly any seeds left to be stored hence 7-8 months of storage was not needed.

More than 57 percent of the farmers reported that they made provisions for light through various modification on the roof and walls, after realizing the effect of diffused light and potential use of it. These farmers used their own seeds for planting in both Yala and Maha seasons.

With regard to ventilation of the storage which is another salient feature of DLS, most of the farmers (86%) disregarded it. However, 34 percent of the farmers made modifications later on this aspect specially when they utilized existing storage facilities and converted them to DLS.

It was evident that the provision of light and ventilation in the storage invariably need exposure to the outside either through the walls or roof. Social environment in the areas was such that they logically feared that, as a consequence, their stored seeds may be stolen and may cause substantial seed losses. Thus, farmers were reluctant to run the risk of exposing their seeds to outsiders other than their families.

Because of this, farmers were motivated to make adjustments to the DLS storage structure again for security, durability and management efficiency. Fifty-two percent of the farmers improved their storage facilities from semi-parmanent to permanent storage structures using expensive materials such as cement for the construction of walls and floor; asbestos, galvanized tin sheets and tiles for the roof; welded mesh behind the windows for extra protection and security; permanent windows with glass sheet and plastic sheets to provide light; and sawed timber for the construction of racks and other features.

There was a gradual adaptation and modification of the temporary and semi-permanent storage structures to parmanent ones. Furthermore, the locally available and cheap materials used for the storage were gradually replaced by capital intensive inputs resulting to the gradual increase of the total cost of the construction.

It seemed that farmers were more concerned about the security of the stored seeds. Thus, this social factor had influenced the farmers to adapt certain features of DLS depending on their situations.

## Farmers Evaluation of DLS Technology and Adaptation Made to DLS During the Adoption Process

Expectedly, certain agricultural technologies are often subjected to farmers' own evaluation and adaptations before they are totally adopted. These adaptations are largely influenced by the variations existing within the farmers' agro-socioeconomic environment. Furthermore, factors which facilitate or inhibit technology adoption are not consistent over time.

The DLS was subjected to numerous adaptations and modifications during the adoption process. Table 27 indicates that 72 percent of the farmers modified their original DLS storage during the trial and adoption periods in various aspects. However, changes in seed storage practices, seed utilization pattern, structure of the storage and in cropping systems, were made even before the DLS was adopted fully.

These modifications occurred over a period of time. Thus this modification and adaptation behavior of farmers in evolving their own technologies would suggest the need for understanding the reasons for such changes and integrating them in future research work in the development of acceptable technologies to the local settings. Horton (1984) also reported on this aspect in his study in Mantaro Valley Project in Andean region.

## Type of Modifications Made on the DLS and Existing Storage Facilities

All farmers who adopted the DLS reconstructed the wooden racks several times. The reasons given by the majority of the farmers was that they underestimated of the seed holding capacity of the racks causing them to break very often. Thus, farmers had to modify the racks using wooden structures to hold more seeds and for more durability.

More than 75 percent of the farmers made improvements on existing storage facilities. Provision of light through added windows and modified roof were the most commonly observed improvement to the existing storage facilities. Table 27 shows the specific modifications made to some parts of the storage structure.

Another apparent change observed was the expansion of the DLS storage after using it for a few seasons. Perhaps, the growing confidence of the farmers on the DLS and the benefits that accrued to them were the motivations that made them expand the storage facility. This also suggested the farmers' economic speculative behavior when they realized the potential of DLS as a facility to store more seeds and sell the excess seeds to others.

Table 27. DLS adoption with modifications, type and frequency of modifications (N=105).

| MODIFICATION | FARMERS Number | Percent |
|---|---|---|
| A. Adoption with and without modifications | | |
| Adoption with modications to DLS | 76 | 72.38 |
| Adoption without modifications to DLS | 29 | 27.60 |
| B. Modifications made to DLS | | |
| Provision of diffused light | 60 | 57.14 |
| Restructuring the racks | 105 | 100.00 |
| Provision of ventilation | 34 | 32.38 |
| Improvement to existing structure using durable materials | 78 | 74.28 |
| Permanent structure | 48 | 45.71 |
| Extension to present storage | 48 | 45.71 |
| C. Number of times modifications were made | | |
| Once | 14 | 13.30 |
| Two times | 38 | 36.00 |
| Three times | 64 | 61.90 |
| Four times | 79 | 15.20 |

## Adopters' Attitude Towards the Present DLS Seed Storage

Only 58 percent (62) of the farmer adopters were satisfied of the present DLS storage facility and the overall performance of the technology under their setting. Obviously this category of farmers was confident in using the DLS without further modification. Thus adoption was sustained. Among the farmers who were not satisfied with the present DLS storage facility (41%) did not totally reject the DLS technology. Their disatisfaction were on the structural component of the DLS rather than on its performance under their agro-socioeconomic environment. This group of farmers were still in the process of modifying the construction of a desired DLS storage rather than reject the DLS. Table 28 indicates the level of satisfaction and reasons for non-satisfaction. Only 21 farmers were planning to construct new storage facilities. These were those who had temporary storage structures.

## The Development of DLS Technology in the Area

Diffused light potato storage technology was developed by the International Potato Center (CIP) through a farmer oriented interdisciplinary research approach (Rhoades and Booth (1982). The specific approaches and the conceptual model concerning DLS technology generation illustrated the strategies and the importance of the interdisciplinary efforts of the technology generation process.

This study was not concerned with the generation of the original DLS technology but examined the subsequent technology developoment process that took place under the farmers' agro-socioeconomic condition in the study area, in evolving an adapted technology.

It appeared that there were several processes by which certain principles of DLS technology had been integrated into the existing storage methods rather than adopt the whole DLS technology in toto. It suggested that even if much efforts have been made to generate technologies that would yield positive gains elsewhere but errors were inevitably committed and failures were still attributed to the inadequate adoption of technology in a specific agro-socioeconomic setting. The process of dynamic adjustment to DLS in response to changing needs and desires of the potato farmers seemed initiated and induced by the DLS technology itself. To cite a striking example, the 12 farmers who initially adopted DLS placed the DLS outside the house but were relocated again in the house with some features of DLS but without diffused light. It was evident that farmers were purposive in their behavior. This re-adaptation purpose had been due, firstly, to avert the risks of keeping seed potatoes exposed to outsiders

Table 28. Adopters' attitude toward the present DLS seed storage (N=105).

| ITEM | FARMERS | |
|---|---|---|
| | Number | Percent |
| A. Level of satisfaction | | |
| Highly satisfied | 14 | 13.33 |
| Satisfied | 48 | 45.71 |
| Not satisfied | 43 | 40.95 |
| Total | 105 | 100.00 |
| B. Principal reasons for non-satisfaction as perceived by adopters | | |
| Not enough space | 35 | 33.33 |
| Need improvement | 34 | 32.38 |
| Temporary storage structure hence need permanent one | 21 | 20.00 |

ensuring the security of valuable seeds; and, secondly, enhanced sprouting of seeds by leaving them in the dark. In another situation, farmers used the traditional storage until the seeds sprouted and then transferred them to the DLS to get the light effect. Thus, farmers were capable of inventing their own technologies using the borrowed principles of DLS to suite their setting and expectations.

The preceding part illustrated that farmers were inclined to change the management practices in the storage after using DLS realizing the fact that mere construction of a DLS storage and use it for seed storage do not yield successful utilization of the technology but it needed certain modifications and adaptation of the whole storage operations. Furthermore, the DLS technology was developed with a pre-occupied generalization that potato farmers in developing countries need relatively low cost storage technology. Some farmers in the study area, however, built DLS storage structures costing even up to Rs. 60,000.00 without any financial assistance from lending institutions. Furthermore, DLS was modified and utilized as commercial enterprise which needed somewhat different seed storage and management practices hetherto unknown to the farmer adopters.

## Identification of Storage Problems

DLS was introduced to the study area at a time when there was no substantial knowlddge about real storage problems encountered by the farmers. Thus, at the early stages of DLS adoption, identification of farmers' storage problem was made concommittantly by the extension agents and other government officials to know the magnitude of the storage problems themselves and to make the farmer aware of them. In this process the most apparent pattern of problem identification in seed storage was the initial perception of the farmers about the problem and later substantiated by the extension agents in the situ. Table 29 presents the problem identification pattern.

The majority (102) of the farmers said that the extension agents helped them to identify the storage problems during their home visits but rarely by research personnel (19) and other government officials (6). Part B of Table 29 shows the various combinations of storage problem identification patterns operated during this stage. Other farmers were not involved in storage problem identification because they also encountered the same problems in the storage.

Furthermore, congruity of perceived seed storage problems between farmers and extension agents and research personnel was perplexing. The contradictory nature of perceived seed storage problems by farmers, extension agents, research personnel and other government officials had negative effects on technology dissemination and adoption processes.

Table 29. Patterns by which potato storage problems were identified (N=105).

| IDENTIFICATION PATTERN | FARMERS Number | Percent |
|---|---|---|
| A. Isolated identification patterns | | |
| Perceived and realized by ownself | 86 | 81.9 |
| Extension agents helped to identify them | 102 | 97.1 |
| Other farmers observed and showed to me | 31 | 29.5 |
| 4. Research personnel helped me | 19 | |
| 5. Other government officials showed to me | 6 | 5.71 |
| B. Combination of identification patterns | | |
| Perceived and realized with the help of extension agents | 58 | 55.2 |
| Perceived and realized and other farmers showed to me | 3 | 2.8 |
| Extension agents and research personnel helped me | 3 | 2.8 |
| Perceived and realized with the help of extension agents and farmers | 20 | 19.0 |
| Perceived and realized through interaction with extension agents and research personnel | 5 | 4.7 |
| Perceived and realized with other farmers and other government officials | 4 | 3.8 |
| Perceived and realized through interaction with farmers, extension agent and research personnel | 4 | 3.8 |

Table 30. Coefficient estimates from maximum likelihood by using Logit procedure, functional relationship between probabilities of DLS technology adoption and explanatory variables (N= 99).

| VARIABLE | BETAa COEFFICIENT | STANDARD ERROR | R-VALUE |
|---|---|---|---|
| Intercept | -16.9161 | 5.0306 | |
| Personal | | | |
| Potato farming experience (x1) | 0.2081* | 0.0889 | 0.169 |
| Extension contract (x2) | 0.5435** | 0.1484 | 0.307 |
| Socio-economic | | | |
| Farm size (x3) | -0.0069 | 0.0066 | 0.000 |
| Seed deficit (x4) | 0.2538** | 0.0984 | 0.196 |
| Storage losses (x5) | 0.1460+ | 0.1141 | 0.000 |
| Occurrence of events (y1 = 1) | = 69 | | |
| -2 Log L, intercept only | = 121.46 | | |
| -2 Log L, convergence | = 30.52 | | |
| Model chi-square | = 90.93, ** 5 df | | |
| Fraction of concordant pairs (Predictive ability of the model) | = 0.982 | | |
| R | = 0.816 | | |

**Significant at 1% level when P < 0.01
*Significant at 5% level when P < 0.05
+Significant at 10% level when P < 0.10

a The algorithum used to solve this problem was a computer programme "Proc Logist" written by Frank E. Harrell Jr., 1980. Clinical Biostatistics, Box 3337. Duke University Medical Center, Durham NC 27710.

Determinants of Diffused Light
Potato Storage Technology
Adoption

The cumulative logistic function model (Pindyck and Rubinfeld, 1978) was used to estimate regression coefficients of variables in order to predict the adoption probabilities. The effect of different variables on DLS adoption was analyzed using logit analysis. Logit analysis is a modification of regression method for situations where the dependent variables are dichotomous in nature. The PROC LOGIST of Statistical Analysis System (SAS) computer package (Harrel, 1980) was applied to estimate the maximum likelihood coefficients of the variables.

Thirteen variables were identified as probably associated with adoption or non-adoption of DLS technology (Appendix F). However, adopters and non-adopters were not significantly different in terms of age and education. Therefore, these variables were not included in logit analysis. Similarly, six other variables: extent cultivated to potato per year, purpose of seed storage, total seed requirement per year, required storage duration, expected number of potato crops per year, and perceived benefits also could not be included in the model due to colinearity with at least one of the variables incuded in the logit model. However, exclusion of these variables did not imply that those variables were not contributing to the adoption of DLS. Table 30 presents the result of the regression analysis.

From that model it was observed that potato farming experience, extension contact and seed deficit were the most important and significant variables that could predict adoption probabilities of DLS, and had significant beta coefficient values at 5 percent and 1 percent, respectively. Furthermore, these variables were postively associated with adoption probability of DLS. However, storage losses was only marginally significant at 25 percent level.

Table 31. Predictive power of the logit model.

| TRUE | PREDICTED Non-Adopters | Adopters | TOTAL |
|---|---|---|---|
| Non-Adopter | 26 | 4 | 30 |
| Adopter | 3 | 66 | 69 |
| Total | 29 | 70 | 99 |

Correct predictive score: 92.9%

The log likelihood ratio for the entire logit model was 90.93 with 5 degrees of freedom. It indicated that the independent variables taken together significantly explained the adoption probabilities of DLS.

Results also showed that predictive ability of the model was very high. In 92.9 percent of the cases the adoption of DLS was correctly predicted by the model. Table 31 shows the predictive power of the model.

## Diffusion Process of DLS Technology

Diffusion of agrotechnologies from the original source to the ultimate end-users took various processes depending largely on the technology, setting, and the delivery mechanism used to disseminate it. The DLS diffusion process should perhaps be viewed with a historical perspective which would eleborate the involvement of the international and national agencies in the early stages of diffusion process, before examining the farm level diffusion of DLS in the study area.

In 1978, CIP post-harvest team took the headway to develop and introduce DLS technology through the regional network of CIP. Initially, DLS technology was introduced to the Philippine potato farmers in collaboration with the national potato programs. It was reported by Potts (1983) that there was a marked acceptance of DLS technology among the farmers in mountain province of the Philippines.

In 1979, a Sri Lankan social technologist was exposed to DLS technology through the regional research trials activities of CIP in Region VII of the Philippines. After his arrival in Sri Lanka, he initially put-up four basic outdoor demonstrations. DLS storage structures were established on government farm sites in Badulla and Nuwara Eliya districts where potato crop was grown, as observation trials. However, government farm's storage conditions rarely matched the condition prevailing in the average potato farmers' storage situations.

Usually, it was customary to test any new technology initially in the national agricultural research network before it is introduced to farmers. However, there were instances where this phase was often omitted and bypassed. Therefore, no monitoring or control of such situations were made even after being specially introduced into the farming community. In the case of DLS technology, it was tested under government farm rather than in agricultural research station which did not have similar conditions with the farmer's situation. With limited information on DLS performance under Sri Lankan conditions, the consultant returned to the Philippines for further advance practical training in CIP post-harvest team under farmers' condition. In 1981, another social technologist from the

extension network of the study area was trained by the CIP Region VII in the Philippines and exposed to the DLS technology which was adopted by potato farmers in Mountain Province, Republic of the Philippines.

While this technology diffusion pre-conditioning was taking place, it would be worthwhile to look into the situation of the locality where DLS was intended to be introduced. After 1977, when there was a policy decision to curtail potato imports in Sri Lanka, there was a gradual increase in potato cultivation. The price of potatoes for consumption also increased substantially in the market. Subsequently, demand for and the price of seed potato also escalated to a considerable degree. Farmers started keeping some of their harvests as seeds.

In this context, it seemed that there was a growing concern among the farmers of seeking a better storage method and the conditions for introducing a technology of this nature to the area were timely and relevant.

In 1980, there were some efforts by the extension agents to introduce DLS technology to the farmers but very little success was achieved as the extension agents themselves lacked knowledge about the DLS technology.

In the early part of 1980, 10 demonstration seed storage structures were constructed in selected family farm units. Of the ten farmers, only two were average farmers and the rest were well-to-do or better-off farmers. These farmers were selected by the extension agent of the area. Some inputs were provided by the government with financial assistance from CIP. However, the cost of construction was less than Rs. 1500 per one ton capacity storage. As expected these farmers never constructed the storage structures which were similar to the government farm demonstration.

They used local materials such as round timber, bamboo slats, mana grass, rice straw, mud and local brick for construction. These structures were more durable, solid and secure as compared to the demonstration storage structure built in government farms. Some farmers used capital intensive material such as galvanized roofing, asbestos, tiles, cement and sawn timber. However, the capacities of the storage did not exceed 2-3 tons. Most of the storage structures were constructed using family labor only. All the 10 farm demonstrations were built outside the residential house. None of the demonstration seed storage structures had adequate diffused light.

Ethnological observations and informal interviews with farmers revealed that the socioeconomic condition of the demonstration farmers with whom demonstrations were established relatively better than the average farmers. It appeared that demonstration sites were selected based on the convenience of the

extension agents rather than of the farmers. Selection was also apparently more biased toward the progressive, resource-rich and known farmers located along the main roads.

Construction of demonstration seed storage took an average of 5 months. After completion of the storage only four farmers were convinced to utilize the storage facility to the full extent while three farmers stored some of their seeds. Three other farmers did not use the storage at all during the first season.

The introduction of a few demonstration seed storage did not per se trigger-off the diffusion of the DLS among the farmers. Farmers around these demonstrations became interested and curious about the technology. There were frequent intensive visits by extension agents to these demonstration sites. At this time, several scientists from CIP also visited these demonstrations and made their comments and observations about its performance in these areas.

In 1981 extensive extension programs were conducted both for extension agents and farmers in collaboration with in-service training institutes in the areas and farmers' demonstrations. A summary of training activities is shown in Appendix Table E. It appeared that there was a strong link and interaction between the CIP and the farm and extension divisions of the Department of Agriculture at the international and regional levels but ironically there seemed to have minimum interactions and linkage with the research division at the national level with regard to DLS technology in the introduction phase.

However, after 1982, farmers' acceptance of DLS had gathered momentum and the adoption trend was discussed in the preceding section.

The foregoing discussion mainly focused on the processes by which DLS technology diffused from the CIP to regional and national levels to recapitulate some of the important events that took place prior to the farm level diffusion of DLS in Sri Lanka.

It was obvious and apparent that there was no clear evidence of the flow of DLS technology through the complex farming community in the study area.

An analysis of the survey data provided some information on the spatial patterns of diffusion processes of DLS over time. Some of the basic reasons for the apparent differences in extension strategy and diffusion were the farmers' strategic locations and differences in resource endowment. In this study, however, three broad spatial diffusion processes of DLS emerged among the farming community. The spatial diffusion of DLS among farmers' over in a 5-year period (1978-1983) are shown in Fig. 5.

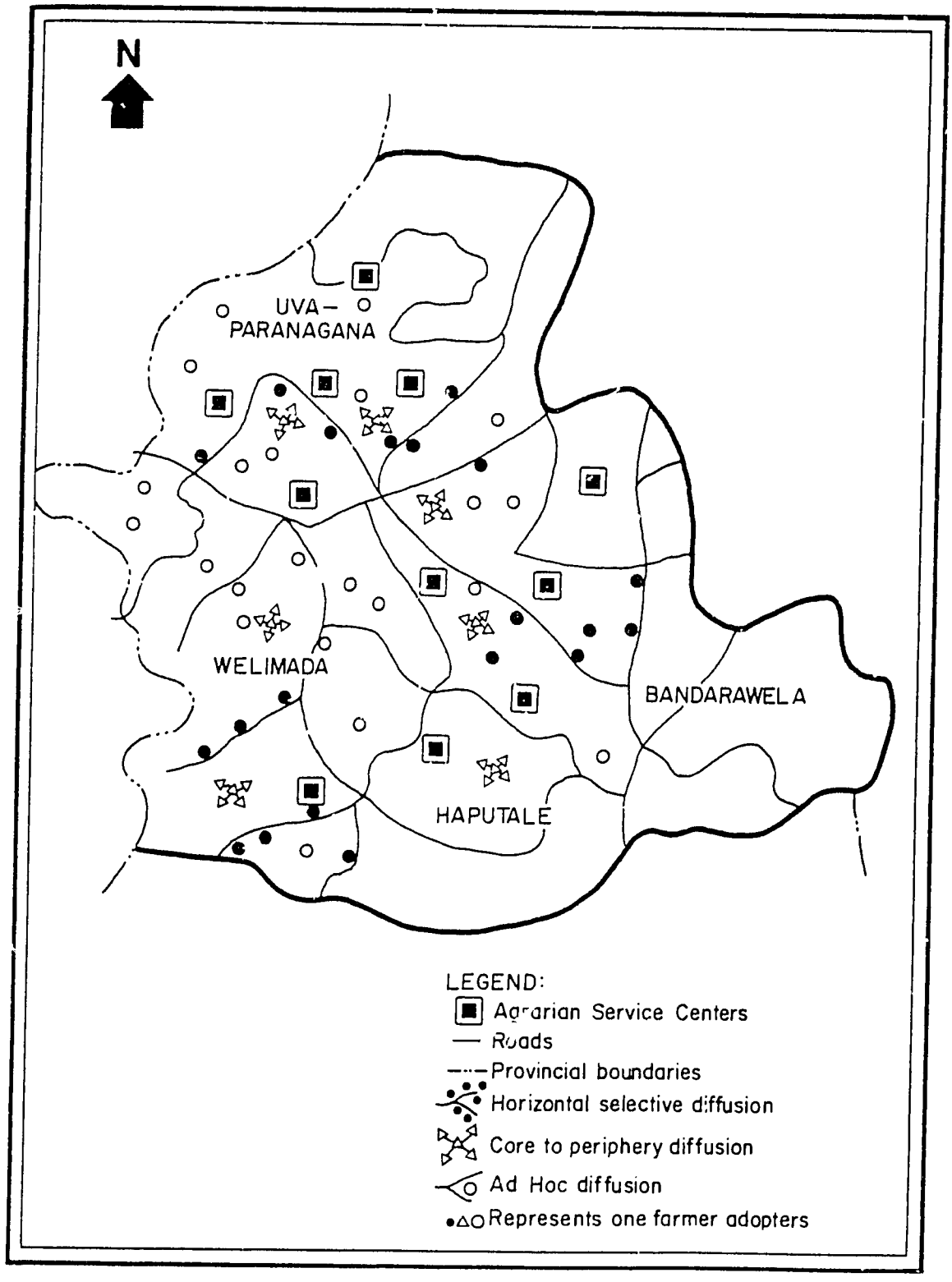



Fig. 5. Spatial diffusion of farmer adopters of DLS during 1978–1983.

## Horizontal Selective Diffusion

Observations during the survey explicitly revealed that there was a professional bias towards some source-rich farms at the initial stages of the introduction of DLS into the area. In analyzing spatial distribution of DLS within the area in 1982 it was found that out of 37 farmers who adopted DLS, 22 farms were strategically located along the main roads. Complementary to this, majority of the farmers were socio-economically well-to-do and had relatively high access to extension information and other inputs. This trend was observed even in subsequent years. This clearly indicated that at the early stages of DLS diffusion process, extension agents selected a group of farmers who were relatively resource-rich, had previous rapport with them, and were easily accessible to them in order to disseminate the DLS. Informal interviews with key informants of the villages revealed that those who adopted DLS initially in their respective villages were more or less prestigious elite of the community and mostly they had contacts not only with the extension agents but also with other government officials and/or services. These category of farmers were continuously subjected to pre-conditioning of the selective delivery mechanisms at the initial stages led to a conspicuous horizontal selective diffusion process of DLS among strategically located resource-rich farmers in the study area (Fig. 6). It was pre-supposed that the spread of DLS would occur subsequently among other less privileged resource-poor farmers after this effort. Ironically, and very often, the branded "progressive farmers" and "contact farmers" failed to impart the new technologies, information to others as they were more often conservative in behavior, in communicating what they learned from extension agents.

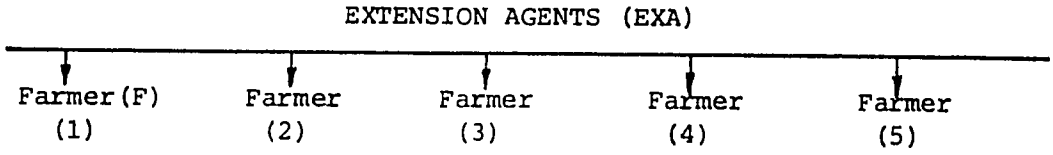
When extension agents were asked as to why they adopted such a strategy and catered to a selected group of farmers, they revealed that one of the reasons for this kind of skeptical extension activity was attributed to the fact that their contacts and the good rapport they established with these farmers even before the adoption of DLS motivated them to start with these categories of farmers. Furthermore, they pre-conceived that these farmers were easy to work with and had easy access to resources. Another reason given by the extension agents was the imposition of targets. They selected initially resource-rich farmers rather than resource-poor farmers, in order to achieve the target.

Therefore, regretabble ignorance of potential resources of poor farmers in initial extension activities apparently shaped the emergence of horizontal selective diffusion process. Similar roadside extension activities were observed in disseminating DLS in the Philippines (Potts, et al., 1982; Acasio, 1984).

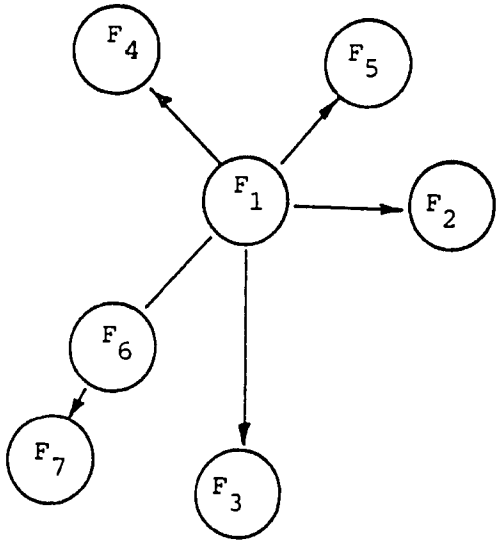
## Core to Periphery Diffusion

From 1982, there was a rapid adoption of DLS as indicated in the preceding section. Extension agents' activities shifted the

1. HORIZONTAL SELECTIVE DIFFUSION




2. CORE TO PERIPHERY DIFFUSION PROCESS




3. AD-HOC DIFFUSION PROCESS

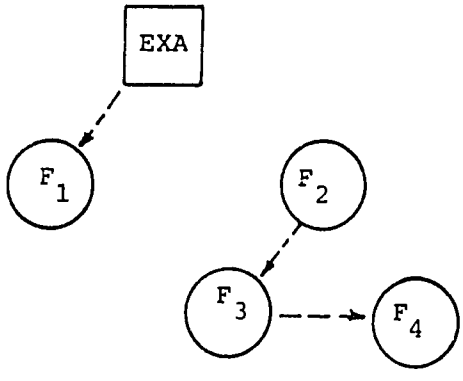



Figure 6. Diffusion processes of DLS during 1978-1983.

emphasis from demonstration and personal contacts to group training activities such as field trips, field days and farmers training classes and they were more committed to interact with adopter farmers. There was a growing awareness among the farmers during this period. It was observed that farmers did not solely depend on extension agents for information on DLS. It seemed that the farmer themselves had an extension network by which DLS spread around some adopter farmers in a radial fashion and adoption proceeded outward the core of adopters. This does not infer that extension activities were not functioning in this set up, but it illustrates the informal extension activities of farmers that disseminated the technology among them. Core DLS farmer adopter functioned as a reference to the other neighboring farmers and he was sometimes considered as the initial information source. He may be located in any place in the community. In this process, the flow of information about DLS was from farmer to farmer. These farmers later functioned as informant to other neighbors in the community. However, this diffusion pattern gradually diminished after six to seven farmers of the village adopted it. This process was observed in other studies also and was termed as "neighbor effect" or "demonstration effect" (Merrill, 1970). Strikingly, the core to periphery diffusion process was by and large a voluntary effort of farmers to choose or improve their existing seed storage within their resource endowment and circumstances. However, the emergence of this kind of diffusion process was only observed after a certain number of farmers adopted the DLS in the study area. It was found that seven clusters involving 62 farmers to have adopted DLS in this fashion. Recognizing the role played by the farmers themselves in disseminating DLS to other farmers it would suggest the strong possibility of considering informal but effective extension agents the farmers as active and important element in diffusion process.

## Ad Hoc Diffusion

The sporadic adoption of DLS within the study area suggested a diffusion process in which farmers' adoption pattern was not apparent and the mechanism of diffusion was not traceable. Adoption of DLS was scattered all over the study area and some of the adopters somewhat remained isolated from other farmer adopters. From the 23 farmers it was gathered that they came to know about DLS from extension agents, relatives and other farmers outside the village. However, self-observation and self-evaluation made them more confident, in using DLS to a large extent. Adoption was voluntary rather than persuaded by extension agents or other farmers. These farmers were more receivers of information rather than givers thus, there were no personal information network between these farmers and extension agents of the area with regard to diffusion of DLS.

Of the 23 farmers, 12 adopted DLS six months after awareness and others took more than 12 months to adopt DLS. It clearly showed that there was no neighboring effect or demonstration effect to the farming community from these conservative farmers. By inspecting their storage structure, it was observed that these farmer adopters often disregarded the use of diffused light concept and adopted strong security measure to prevent any theft or outside intervention. However, this diffusion process suggested that often diffusion technology could operate unnoticed under certain circumstances.

## Analysis of Interactions and Communication Between and Among Farmers, Extension Agents, Research Personnel in the Development, Adoption and Diffusion Process of DLS Technology

A brief analysis of interactions and communication network between and among various disciplines involved in DLS technology development, diffusion and adoption was employed to understand the roles played by these sectors in the advancement and sustenance of these processes.

### Interaction and Communication Among Farmers

Interaction and communication among farmers were predominantly interpersonal, face-to-face and informal (100%). Almost all of the farmers agreed that they had adequate time and opportunities to interact with each other.

More than 36 percent of the farmer adopters sought information from the immediate DLS adopters. But the majority sought information from other sources too, such as extension agents, official of the cooperatives and other development workers in the village. Table 29 in the previous part showed that 31 farmers identified their storage problem as a consequence of interactions with other farmers. Table 21 indicated that farmers' interactions with other farmers were more intensive in the adoption process and 70 percent of the farmers interacted and communicated to each other on the practical utilization of DLS.

It appeared that there were a few farmers in the village who were contacted more often than other farmers on agricultural information. These farmers were considered as village leaders or key informant farmers who had relationships with sources of information and interaction between farmers and key informants were intensified after the adoption of DLS. It was found that the use of traditional village elites were very effective in the communication of information and in the process of diffusion of technology. Village leaders, key informant officials of the cooperative store and rural development society had all

contributed with varying degrees of success to the diffusion of DLS in the area. The role of village elites in diffusion of innovations were also elaborated by Joof (1980).

Farmer adopters as primary source of information on DLS played a vital role in DLS adoption process. Table 22 of the preceding section showed that other farmers and village leaders' influence was more at the trial and adoption stages of the adoption process.

Sources of Information of Farmers on Seed Storage Problems After Adoption of DLS

Table 32 summarizes the sources of information on DLS technology after its adoption. The most predominant source of information was the extension agents followed by farmer adopters. This was expressed by 99 and 69 percent of the respondents, respectively. This trend indicated the growing interaction among the farmers after adoption of DLS. Even the non-adopters were considered as information source (49%). Perhaps such information sources helped them to dispose excess seeds and bought freshly harvested seeds.

Table 32. Sources of information of farmers on seed storage problems after adoption of DLS.

| SOURCE | FARMERS | |
|---|---|---|
| | Number | Percent |
| Extension agents | 104 | 99.04 |
| Research personnel | 28 | 26.66 |
| Adopters of DLS | 72 | 68.57 |
| Non-adopters of DLS | 52 | 49.52 |
| Village leaders | 46 | 43.80 |

There was a significant increase in interaction between village leaders (44%) and to a lesser degree with research personnel after the adoption of DLS.

The propensity to seek more information from various sources likely indicated that farmer adopters encountered more storage problems after the adoption of the DLS. Perhaps, they were not confident about what they already knew. It was evident that there was a marked shift in the choice of information source after the adoption of the DLS.

## Perceived Nature of Information from Farmers, Extension Agents and Research Personnel

One's behavior is guided by the perception he holds and alternative actions are chosen according to his belief. By analogy the quality of information the frmers get from various sources may greatly influence his perceptions and likelihood of acceptance of the new idea. The differences discussed were primarily concerned with three main sources of information. Table 33 revealed that there were significant differences in the farmers' perception with regard to the quality of information they got from extension agents, research personnel and other farmers.

Ninety-five percent of the farmers believed that other farmers provided practical information in comparison to research personnel (6%). The majority of the farmers said that extension agents (68%) were more credible than either the farmers (53%) or research personnel (10%) as far as quality of information is concerned. However, 45 percent of the farmers considered the research personnel as a source of expert information. In the case of other farmers, there were only 19 percent farmer adopters who perceived that they got expert information from this category. Nevertheless, the influence of perception on the quality of information from these three sources was not evident on farmers adoption behavior.

Very likely the farmers' differences in perceptions about the sources of information might have an effect on the choice of information from different sources. If farmers have availed of expert information from extension and research personnel, this might have substantial influence in the adoption of DLS. However, the farmer adopters' contact and relationship with research personnel seemed to be exceedingly minimal.

Table 33. Perceived nature and quality of information on DLS available to the farmers from other farmers, extension agents and research personnel.

| QUALITY OF INFORMATION | FROM FARMERS | | FROM EXT. PERSONNEL | | FROM RESEARCH PERSONNEL | |
|---|---|---|---|---|---|---|
| | No. | Percent | No. | Percent | No. | Percent |
| Practical | 90 | 85.71 | 87 | 82.85 | 6 | 5.71 |
| Problem solving | 77 | 73.33 | 73 | 69.52 | 4 | 3.80 |
| Relevant | 80 | 76.19 | 71 | 67.61 | 13 | 12.38 |
| Credible | 56 | 53.33 | 72 | 68.57 | 11 | 10.47 |
| Expert | 20 | 19.04 | 63 | 60.00 | 47 | 44.76 |

Table 33 indicated that the quality of information from farmers was regarded as practical, relevant, problem solving and credible. Furthermore, interaction with farmer adopters were relatively higher than the non-adopter farmers as far as seed storage problems were concerned.

It was evident that interaction among farmers during the technology generation phase were not conspicuous. However, reciprocal interdependence of farmers' information on DLS during the later stages of adoption process through interactions played a vital role in evolving their own technologies. Farmers' communication environment had been always conducive for interpersonal informal interactions. These interactions also played an important role in disseminating DLS to a substantial proportion among other farmers. Relative homogenity of the farmers in terms of agro-socioeconomic environment had influenced thse intensive interactions among farmers coupled with their kinship relationships. Farmers' initial interaction patterns across the farming community followed the adopters, village leaders and non-adopters, respectively, in adoption and diffusion process of DLS.

## Interaction Between Farmers and Extension Agents

The study showed that frequent interactions took place between extension agents and farmers during the process of development, adoption and diffusion of DLS. The nature of interactions was mainly interpersonal and group contact.

The complex interactions that took place during the farmers' evaluation and adoption stages were considered the phase in which farmers attempted to develop their own technologies by integrating DLS principles in their setting. Extension agents' contact with farmers is given in Table 34.

Table 34. Rank distribution of extension agents and farmers according to choice of communication channel.

| CHANNEL OF CONTACT | EXTENSION AGENTS' PREFERENCE (Rank Order) | FARMERS' PREFERENCE (Rank Order) |
|---|---|---|
| Personal contact (Informal contacts, home visit, field visit by extension agents) | 2 | 1 |
| Group activities (Field trips, field days, demonstration) | 1 | 2 |
| Group contacts (Farmer training classes, group discussions) | 3 | 3 |

As shown on the table, farmers preferred extension agents' personal visit to their home or to the farm while extension agents preferred group activities as a means of contact. Ironically, it was found that other contact methods, involving mass media - printed matter, radio, television and agricultural exhibitions were never used in any stage of adoption or diffusion process.

Analysis on the initiation of such contacts and interaction between farmers and extension agents revealed that extension agents took more the initiative in this respect. Table 35 shows the initiative behavior of the farmers and the extension agents.

Table 35. Percentage distribution of farmers and extension agents initiative behavior by contact method.

| CHANNELS OF CONTACT | CONTACTS | |
|---|---|---|
| | Initiated by Farmers | Initiated by Extension Agents |
| Personal contacts | 33 | 67 |
| Group activities | 31 | 69 |
| Group contacts | 14 | 86 |

Majority of the farmers' contacts were initiated by the extension agents in all he channels used. To some extent, these findings supported the earlier premise that extension agents served as the mechanism that fosters and accelerates diffusion of innovation (Wirasighe, 1977, Long, 1977). However, other researches found that they often failed to accomplish the mission assigned to them and the extension services were ineffective in this endeavor (Clemente 1971, Coombs and Ahmed, 1974, Tautho, 1985, Tan, 1984). The majority of the adopter farmers (86%) felt that opportunities and frequency of contacts with extension agents were adequate for effective interactions.

## Extension Methods and Strategies Used to Disseminate DLS and Their Effectiveness

Various extension methods and strategies which are used to disseminate a technology had different effects depending on the clientele and the situation. Table 36 presents the extension methods mostly used and rated according to their effectiveness. All of the farmers indicated that personal visits by extension agents were very useful and effective with a mean weighted average of 3.57. The majority of the farmers said field trips to other farms organized by the extension agents were useful and effective (weighted average: 3.15). Field days and farmer

training classes were rated as fairly useful. Although 84 of the farmers attended farmer's training classes, the average rating was only 2.0 and was described as fairly useful. The farmers' group discussion as an extension method was rated by farmers as not useful and less effective.

Table 36. Extension methods and strategies used to disseminate DLS and farmers' opinion on the usefulness and effectiveness of the activity.

| EXTENSION ACTIVITY | NO. OF FARMERS | WEIGHTED AVERAGE | RATING |
|---|---|---|---|
| Personal visit by extension agent to house | 105 | 3.57 | Very useful and effective |
| Field trips to other farms with extension agent | 91 | 3.15 | Useful and effective |
| Farmer training classes | 84 | 2.00 | Fairly useful |
| Visit to demonstration in the area | 30 | 2.36 | Useful and effective |
| Field days | 21 | 2.00 | Fairly useful |
| Farmers' group discussion | 11 | 1.36 | Not useful and less effective |

The findings suggest that personal visits by extension agents made farmers aware of the DLS and field trips to other farmers' storage got them more interested. Visits to demonstration or the neighbor farmers' storage helped farmers to evaluate DLS in their own situation.

Extension agents however viewed field trip as the most effective extension method. Next to field trip is the personal visit to the farms. Appendix Table C shows the ranking of the various extension methods.

## Extension Contact with the Members of the Family

As discussed in the preceding sections, the role played by the housewife and children in crucial farming operations suggest that they also be considered as vital extension clientele if agricultural information were to be communicated to the farming community. Ironically, extension agents disregarded the housewife and children to a greater extent and focused their

attention mainly on male farmers. Table 37 illustrates the nature of contacts with other members of the family.

Historical and ethnological background of women and children participation in diverse agricultural activities were clearly evident. Thus, by-passing women farmers and children as potential clientele of extension agents would have some degree of influence on the diffusion and adoption of DLS. The negligence of considering women and children in extension activities were also reported by several researchefs (Joof, 1980, FAO, 1984, Staudt, 1976).

Table 37. Percentage contact of extension agents with members of the farm family.

| EXTENSION AGENTS CONTACT METHOD | EXTENSION AGENTS CONTACT WITH | | |
|---|---|---|---|
| | Farmer | Wife | Children |
| Farm visits and field visits | 81 | 15 | 4 |
| Group contact | 93 | 2 | 5 |
| Group activities | 90 | 4 | 6 |

Purpose of Interaction

The purpose of farmers' interaction with extension agents are given in Table 38.

The ranking on the table indicated the incongruency of the perception of extension agents and farmers regarding their motives and needs. The extension agents perceived that providing information on the technical aspect of DLS construction was the most important need but farmers said that information on pest and disease control was the most needed aspect they expected from extension agents. These differences in purpose of interaction and contents were also reported by Lakoh and Akinbode (1981).

Table 38. Aspects and order of importance of interaction that took place between farmers and extension agents during the DLS technology diffusion and adoption processes.

| VARIOUS ASPECTS | RANK ORDER | |
|---|---|---|
| | Extension Agents | Farmers |
| Technical aspect of DLS construction | 1 | 5 |
| Pests and diseases control in storage | 2 | 1 |
| Modification of existing storage facility | 3 | 2 |
| Management practices | 4 | 1 |
| Utilization of seeds | 5 | 3 |

## Interaction Between Farmers and Research Personnel

Table 32 in the preceding section showed that research personnel interaction with farmers during the DLS technology development and diffusion processes were minimal. Whatever the little link they had with research personnel was limited to occasional field visits. Farmers strongly expressed that the opportunities and frequencies of contacts with research personnel was extremely inadequate. Only six farmers said that they had acess to research stations. However, 46 percent of the farmers believed that research personnel could provide expert information on agricultural problems.

In the light of the foregoing discussion, there was a minimal link between the farmers and research personnel throughout the DLS development and diffusion processes within the study area. It was considered that this link was an essential linkage that would enhance the adoption process as well as the new technology generation by understanding the farmers' situation and integrating those findings in future research work (Rhoades and Booth, 1982, Chambers and Ghildyal, 1985, Chambers, 1982 and IDRC, 1984).

## Interaction Between Extension Agents and Research Personnel

The findings of the study revealed that there was a considerable interaction between middle level extension agents and research personnel. However, it was noted that the interactions and communication between the village level extension agents and the research personnel seemed to be exceedingly poor. This was reported by 50 percent (17) of the extension agents. Furthermore, extension agents felt that they had more opportunities to interact with researchers at the research stations and in training sessions but they lack opportunities to meet them in the farmers' field where actual field problems exist. More than 86 percent (24) perceived this.

Informal interviews with research personnel involved in on-farm research (adaptive research) revealed that they were burdened with basic research work in the research station and faced with difficulties in finding time to visit the farmers' fields with the extension agents. Furthermore, they considered on-farm research work in the farmers' field as additional work. They would like to concentrate on-station research which have better prospects for recognition and rewards. Similar findings were reported by Chambers (1981).

It was found that much of the interactions between extension agents and research personnel who engaged in potato research work were mostly confined to off-farm formal places such as research

station, training sessions held in training centers and working group meetings. In some instances, extension agents brought seed storage problems during the encounters and most of the problems were on pests and diseases during storage as well as in the crop. More than 46 percent of the extension agents expressed that research personnel were often unable to give practical solutions to most of the problems presented to them.

Extension agents interacted with research personnel at the trial stage of adoption process more than any other stage. This was revealed by 83 percent of extension agents as they encountered more problems during the adoption phase.

The level of interaction was examined and Table 39 presents the extension agents' contacts with research personnel.

Table 39. Level of contact between research and extension personel as perceived by extension agents.

| EXTENSION AGENT'S CHANNEL OF CONTACT | LEVEL OF CONTACT WITH RESEARCH PERSONNEL | | |
|---|---|---|---|
| | High | Medium | Low |
| Personal visit to research station | | | / |
| Personal visit by research personnel to the field | | | / |
| Training classes and in-service training | / | | |
| Seasonal training at in-service institute | / | | |
| Training classes in the fields | | | / |
| Demonstrations | | | / |
| Group visit to research station | | / | |

These findings would direct to the attention that there is a need for an interaction between researchers and change agents in the farmers' field where the problems are and this may be imposed or institutionalized by research and extention network oparating in the area.As Rhoades (1984) emphasized there is an urgent need for researchers to go beyond the technology designing and follow-up so that what is happening in the farmers' fields would enable them to understand the farmers' real needs and resource constraints and evaluate how far the offered technologies are addressed to their needs.Thus,lack of farmer-research dialogues in the adoption and diffusion process of DLS technology would impede the rare and valuable opportunity of research personnel to learn from the farmers so that they may be incorporated in future research work in designing acceptable technologies.

Interactions with extension agents and research personnel were mainly on the problems encountered by the farmers after the adoption of DLS. At this stage, both extension agents and farmers were learning from each other about the DLS. Thus, extension agents might have filtered the farmers' problems through the fabric of perceptions they held, and interpreted them to the research personnel.

Therefore, research personnel isolation from farmers would result to a confusion in communication and perceptions. It would also lead to failure in understanding the farmers' real problem associated with DLS adoption.

### Interaction of Non-Adopter with Extension Agents, Research Personnel and Farmer Adopters

The analysis of interactions between non-adopter and extension agents, research personnel, farmer adopters showed that there was a considerable contact with extension agents and adopter farmers. Table 40 presents the non-adopters interaction

Table 40. Interaction of non-adopters of DLS with extension agents research personnel and farmer adopters (N=30).

| PERSON INTERACTED | NON-ADOPTERS INTERACTION OPPORTUNITIES | | | |
|---|---|---|---|---|
| | Adequate | | Not Much | |
| | Farmers | | | |
| | Number | Percent | Number | Percent |
| Extension agents | 27 | 90.00 | 3 | 10.00 |
| Research personnel | 4 | 13.30 | 26 | 86.70 |
| Farmer adopters | 28 | 93.30 | 2 | 6.70 |

level. The non-adoptrs perceived that they had adequate opportunities to interact with extension and farmer adopters as compared to research personnel. It was also revealed that contacts with non-adopters were mostly interpersonal (83%) rather than group contacts (17%).

### An Overview of Interaction that Took Place in the DLS Adoption and Diffusion Process

The foregoing discussions revealed that there was a complex network of interactions between and among farmers, extension

agents and research personnel in varying degrees at various stages of DLS diffusion and adoption process (Table 41).

The initial introduction of DLS, interactions between extension agents and farmers was mainly focused on identifying

Table 41. Overall interaction matrix among and between farmers, extension agents and research personnel in DLS adoption and diffusion processes.

| PERSON | PERCEIVED INTERACTION LEVELS | | |
|---|---|---|---|
| | Farmers | Extension Agents | Research Personnel |
| Farmers | Adequate | Adequate | Inadequate |
| Extension Agents | Adequate | Adequate | Inadequate |
| Research Personnel | Inadequate | Moderate | Adequate |

storage problems and evaluating the magnitude of the problems in situ. During this stage, not only extension agents but also farmers became aware of the present storage problems. This was facilitated and supplemented largely by the intensive training programs organized for farmers, extension agents, research personnel and other goverment officials involved in potato production in collaboration with in-service training institutes, government farms, research stations and farmers. Details of the training activities are given in Appendix E.

Subsequent establishment of the field demonstrations in farmers' fields had facilitated more opportunities for extension agents and research personnel to interact with the early adopters of DLS.

Some emerging problems were identified by farmers as well as the other personnel who were interested in the dissemination of DLS. At this stage, interaction between local scientists, farmers and international scientists from CIP also took place. These interaction helped those concerned to understand the DLS technology performance and the associated problems under the farmers' conditions.

Interestingly, these complex interactions between and among various disciplines helped farmers to generate their own storage technologies using the basic principles of DLS under their agro-socioeconomic environment. These innovations of the farmer adopters guided and influenced the extension agents to a larger extent in disseminating DLS to other farmers.

Although interactions between farmer adopters and non-adopters were predominantly face-to-face in nature, there

appeared to be an existing and effective internal informal communication and information exchange network in which DLS technology diffusion occurred. There should be a firm link between farmers and research personnel at all stages of adoption and adaptation of technologies if emerging constraints were to be fedback to technology generation process (Rhoades, 1984d) and to provide a rich variety of opportunities for research personnel (ICRISAT, 1980) to learn from the professional farmers (Chambers, 1985). Ironically, there were only limited opportunities for both farmers and researchers to interact with each other in the case of DLS technology, diffusion adoption and process.

## Agro-Socioeconomic Impact of DLS

This part focuses on the impact of DLS firstly on the farming system and secondly on the socioeconomic system of the farmer adopters.

### Agronomic impact of DLS

Changes in cropping area. Table 42 sumamrizes the changes in area planted to potato in terms of land sizes for both Maha and Yala seasons. It clearly showed that all the potato farms planted to potato increased in area. On an overall basis the average of increase in both Yala and Maha seasons for all the land categories were relatively proportional to the respective size of landholdings except for the last two land categories.

The minimum average increase in area was 0.18 hectare, while the maximum was 0.76 hectares. The data revealed that all the land size categories were benefited by DLS. Thus, differential access to land was not an impediment to adopt DLS.

Impact on land utilization. Table 43 enumerates the strategies used to increase the area for potato cultivation. It was notable that 100 percent of the farmers rented additional land to increase the ptoato area after adoption of DLS. But there was a decline in area for the growing of other crops such as cabbage beans, tomato, radish, etc. from their cropping system. This trend was observed among 40 farmers. This was probably due to the increasing availability of potato seeds and partly due to scarcity of arable lands. Another strategy used by farmers to increase area for potato cultivation was the use of hitherto un-utilized lands. Only 40 farmers reported this but it was found that there was a downward trend in potato cropping intensity on the highlands and other lands. Thus, this suggested a longer crop rotation in this lands paricularly with potatoes.

Changes in potato cropping sequences. Table 44 reflects the increased potato cropping sequence. Usually farmers grow at least two crops of potato per year (Maha and Yala) on different land categories. After the adoption of DLS, it was observed that farmers did not only increase cropping intensity in a particular land category but also increased the number of potato crops grown

Table 42. Increase of farm area to potato cultivation as a result of DLS adoption (N=105).

| FARM SIZE CATEGORY (Ha) | NO. OF FARMS | NO. OF FARMS THAT INCREASE POTATO CROP | % OF SIZE CATEGORY | AVE. EXTENT (Ha)INCREASED IN MAHA & YALA SEASON |
|---|---|---|---|---|
| 0.4 and less | 23 | 23 | 100.00 | 0.1781 |
| 0.5 to 0.8 | 27 | 25 | 92.59 | 0.2874 |
| 1.9 to 1.2 | 27 | 22 | 81.08 | 0.3373 |
| 2.1 to 2.4 | 8 | 8 | 100.00 | 0.4773 |
| 2.5 and above | 10 | 9 | 90.00 | 0.7611 |

Table 43. Strategies used by farmers to increase the potato crop.

| STRATEGY | FARMERS | |
|---|---|---|
| | Number | Rank |
| Increase area cultivated by renting out lands | 105 | 1 |
| Replacement of other crops in cropping system | 40 | 2 |
| Use of un-utilized land for potato cultivation | 40 | 3 |
| Share cropping with other farmers | 15 | 4 |
| Increased cropping sequence in cropping system | 71 | 2 |

following different times of planting. Perhaps this staggered cultivation of potatoes in different land categories was possible because of continuous availability of seeds. Such alteration in cropping sequence would largely offset the cropping pattern of the farmer adopters.

Changes in share cropping. Share cropping still remains a quite prominent practice in the study area especially between land-rich and land-poor farmers. But in the case of potato cultivation the share cropping arrangements were between seed-rich

and seed-poor farmers. However, only 15 farmers reported that they started share cropping with seed-poor farmers by using the excess seeds and expanded area cultivated to potato.

Changes in potato cultivation practices in the cropping system. Farming system in the study area was a complex and integrated system in which any change in potato cropping system can cause by and large a significant change in the whole farming system.

With the adoption of DLS one of the most direct impact that was observed was the availability of more potato seeds in the family farms. Table 44 presents the major direct changes that occurred in the potato production system after the adoption of DLS.

Table 44. Changes in potato cultivation practices after adoption of DLS. (N=105)

| PRACTICE | FARMERS | |
|---|---|---|
| | Number | Percent |
| Extended planting season | 102 | 97.14 |
| Regular harvest throughout the season | 100 | 95.03 |
| Staggered planting time | 76 | 72.38 |
| Change in cropping pattern | 42 | 40 |
| Seed selection from own harvest | 14 | 13.3 |

Almost all of the farmers (102) changed their potato planting seasons. Prior to DLS adoption there were only two predominant seasons, i.e. Yala and Maha seasons. With the introduction of DLS farmers extended their planting season from June to late September in Yala season and October to late February in the Maha season in contrast prior to the adoption of DLS which was July to August in Yala and late November to early February in Maha season.

Another significant change in the cropping system was staggered planting of potatoes. This may be attributed to the seed availability at different planting time which was not experienced before the adoption of DLS. This also facilitated the use of well-sprouted seeds in small quantities with intensive care and use of capital resources judiciously among the farmers. One of the problems faced by the potato farmers in this area was the glut of potatoes at harvest time, especially during the Yala season. Farmers were compelled to dispose of their produce at a low market price. Staggered planting not only eased this critical situation but also sustained and facilitated income generation throughout the season. More than 95 percent of the farmers harvested potato crop regularly for a longer period as compared to the previous of one or two harvests only.

Table 45. Comparison of overall improvements in potato crop as perceived and realized by farmer adopters before and after adoption of DLS (N=105).

| AREA OF IMPROVEMENTS | NO. OF FARMERS BEFORE DLS | NO. OF FARMERS AFTER DLS | % INCREASE OVER BEFORE DLS |
|---|---|---|---|
| A. Emergence of crop | | | |
| Early | 16 | 96 | 76.19 |
| Late | 21 | 9 | -11.42 |
| Uneven | 68 | 0 | -64.76 |
| B. Incidence of pests and diseases | | | |
| High | 34 | 16 | -17.14 |
| Medium | 83 | 61 | 7.61 |
| Low | 15 | 28 | 12.38 |
| C. Maturity of the crop | | | |
| Early | 34 | 88 | 60.95 |
| Late | 81 | 17 | -60.95 |
| D. Yield | | | |
| High | 1 | 64 | 60.00 |
| Medium | 60 | 41 | -18.09 |
| Low | 44 | 0 | -41.90 |

Change in Cropping Pattern. Until recently, many farmers in the study area had the impression that only one potato crop can be grown in the paddy fields after rice harvest. Furthermore, they were using paddy varieties which mature in 5 1/2 months under local conditions. Three farmers experimented on two potato crops and one rice crop in paddy fields successfully. The specific cropping pattern is given below. Similar trend was reported by Rhoades (1984) on this aspect.

| | rice | | potato | | potato/pumpkin/ sweet potato | |
|---|---|---|---|---|---|---|
| Jan 15 | | June 20 | | Sept. 10 | | Jan.10 |

Overall improvement of the potato crop. A comparison of the overall improvement of the potato crop before and after the use of DLS seeds as perceived by the farmer adopters was made. Table 45 summarizes the comparison.

It was evident that before the adoption of DLS the general condition of the potato crop was poor (using both own-produced seeds and seeds from outside sources) with regard to emergence, pest and disease conditions, maturity and final yield.

Table 45 shows that uneven and late emergence (89), high and medium pest and disease incidence (87), late maturity and low yields (104) as perceived by farmers elaborating the magnitude of the presumed low quality of potato crop before adoption of DLS. In contrast, farmers perceived that after using DLS stored seeds emergence of crop was early (96) incidence of pest and disease was low and medium (89), early maturing crop (87) and higher yields (105).

However, it appeared that these results had overestimated the overall impact of DLS seeds as will be seen in Table 46 regarding the income generation after adoption of DLS.

Table 46. Comparative changes in income and level of increase as assessed by farmer adopters before and after adoption of DLS.

| PERCENTAGE INCREASE IN INCOME | LEVEL OF INCREASE | NUMBER OF FARMERS Number | Percent |
|---|---|---|---|
| Less than 10% | Very little | 3 | 2.85 |
| 11% - 20% | Less than average | 42 | 40 |
| 21% - 30% | More than average | 52 | 49.52 |
| 31% - 40% | Substantial increase | 8 | 7.6 |
| Total | | 105 | 100.0 |

## Social Impact of DLS

After adoption of DLS several favourable and unfavourable social impact were noticed among the farm families. Table 47 shows the social impact as enumerated by the respondents.

Social participation. There was a significant and positive increase in participation of farmers in agriculture extension programmes (59%) and high level of social participation (69%) (Table 47). It was indicated that farmers were exposed not only in social activities but also in extension activities. This was due to extension agent's contacts and the social recognition given them as seed storage owners in the community.

However, 65 percent of the farmers claimed that after adoption of DLS, they were often expected to play additional roles given or assigned by extension agents and government officials, such as staying in the house when other farmers, visitors and government officials visit their DLS storage and acted as resource persons. In some instances, they had to forgo their day-to-day work and devote the time for this kind of involvement. Seemingly social participation was a precondition for the DLS and also a post-consequence for sustenance of the adopted technology.

Social prestige and recognition in the community. Table 47 also shows that farmers had the growing recognition as a reliable seed source in the community by other farmers. Some farmer adopters were also faced with the problem of providing assistance to other farmers with respect to seed supply without monetary involvement. Threfore, this was an imposed social obligation to the farming community which sometimes they cannot afford.

Expected relief on drudgery involved in seed handling. Consistently farmers said that they were faced with tedious work when they sorted rotten tubers in traditional storage facilities. As DLS adopters, farmers thought that they had been relieved considerably from the drudgery of seed handling. Because DLS provided ample space to facilitate easy inspection routinely thus, excessive rotting was arrested. More than 43 percent of farmers reported that they were relieved from this tedious work involved in seed handling.

Changes in attitudes in potato cultivation. Despite the fact that farmers realized low yields when imported seed potatoes which usually arrived late were used and experienced enormous hardships in purchasing seeds, they had the impression that imported seeds are musts in seed potato production. However, this attitude changed drastically when they knew that higher yields were obtained when they planted localy produced seeds with proper condition and time. The adoption of DLS also changed the attitude in handling seed tubers especially during the storage phase. Careful selection of seeds and recognition of seed tubers

Table 47. Impact of DLS on the social aspect of farmers and their family members (N=105).

| IMPACT | NUMBER OF FARMERS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Very Much | | Much | | Not at All | | Total | |
| | No. | Percent | No. | Percent | No. | Percent | No. | Percent |
| Participation in more agricultural extension programmes | 61 | 58.09 | 44 | 41.90 | - | - | 105 | 100.00 |
| Contact with extension agents | 64 | 60.95 | 41 | 39.04 | - | - | 105 | 100.00 |
| Contact with research personnel | 7 | 6.66 | 11 | 10.47 | 87 | 82.25 | 105 | 100.00 |
| Participation in social organizations | 5 | 4.76 | 37 | 35.23 | 63 | 60.00 | 105 | 100.00 |
| Kept busy with farmers and other officials | 29 | 27.61 | 68 | 64.76 | 8 | 7.61 | 105 | 100.00 |
| Recognition in the village as a reliable source of seed | 34 | 32.38 | 64 | 60.95 | 7 | 6.66 | 105 | 100.00 |
| Relief from drudgery involved in seeds handling | 27 | 25.71 | 66 | 62.85 | 12 | 11.42 | 105 | 100.00 |
| Relief from hardships involved in acquisition of seed | 46 | 43.80 | 51 | 48.57 | 8 | 7.61 | 105 | 100.00 |
| Family members' involvement in seed storage | 34 | 32.38 | 50 | 47.61 | 13 | 13.38 | 105 | 100.00 |

as living materials were important attitudes that influenced the farmer in producing good quality seeds.

One of the crucial attitude changes in storage was bringing seeds from "dark" to "light". Farmers stored seeds for more than two decades in the dark places. This practice was advocated by the extension delivery mechanisms at the early stages of the introduction of potato crop in the area. However, it seemed that keeping seeds in diffused light is still undergoing informal evaluation by farmers for justification.

Impact on the availability of seeds. Previously, farmers encountered enormous hardships in fulfilling their seed requirements from outside seed sources. More than 80 percent of the farmers said that DLS somewhat lessened the tedious hardships involved in acquiring seeds from government and other seed sources.

Institutional impact of DLS. One of the broader social impacts on family members' involvement in storage was the relative increased contribution and the cooperation among each family member after the adoption of DLS. More than 32 percent of farmers reported that as a consequence of DLS there had been changes in potato cropping pattern and associated activities which involved family members more intensively. Seed storage was a family affair and it demanded more participation due to changed and increased storage practices and activities throughout the storage period.

This perhaps had absorbed the family members' leisure time considerably. This had disturbing implications to the other farming activities and the emerging constraints might impose further adaptations on the DLS.

Furthermore, the DLS technology created more opportunities for farmers to improve their relationship with his social environment but also generated new problems for them such as evil eye and insecurity of stored seeds.

It was found that the DLS technology dissemination initiated several training and extension activities in training institutions and in extension delivery mechanism, not only on aspect of DLS technology but also related on potato production technologies (Appendix E).

By-passing the national agricultural research network at the initial phase of DLS technology, evolved a new set of problems both for farmers and extension delivery system, especially when they encountered storage problems associated with DLS such as pests and diseases, structural designs and modifications. It was a difficult task to convince the existing research system to look into these emerging problems of DLS and integrate them in the research priorities of the research institutions.

It was also observed that the use of DLS had increased the seed availability in the farmers' seed system. This led also to alleviate the pressure imposed on the government potato seed distribution system to a certain extent. After the introduction of DLS to the farmers, it appeared that government seed distribution system also became aware of the potato storage problems in the existing storage structures and the improper storage management practices. Recognizing these problems and limitations of existing potato storage, the structure were modified and imiproved using the basic principles of DLS technology.

## Economic Impact

This section attempted to explain some of the economic impacts that were observed after adoption of DLS in family farming systems. It was expected that DLS would diversify the use of resources and would lead to considerable economic gains.

Changes in family farm income. Table 46 indicated that after the adoption of DLS the total income of the family had increased considerably. As much as 57 percent of the farmers believed that they were able to increase their total annual income from 21 to 40 percent. Among them eight had a substantial income increase while the rest of the increase was just more than average. Only three farmers revealed that the increase in income was less than 10 percent only. However, all the farmer adopters were able to increase their farm income.

Changes in cost of production of potatoes. The cost of production per hectare of potato increased rapidly during the last five years due to rapid increase of prices of inputs and increased use of farm inputs. Table 44 shows the cost of production of potatoes before and after adoption of DLS.

It was noted that there was an almost three-fold increase in the cost of seeds per hectare during the time span from 1982 to 1984, before and after the DLS adoption. This drastic increase in seed cost may be a contributing factor to the adoption of DLS.

Changes in the Yield. Table 45 showed that 60 percent of the farmer adopters perceived that there was a yield increase after using DLS seeds. Rhoades (1984) study also supported these findings. More than 94 percent of adopter farmers reported that yield increase was due to the use of DLS which was particularly influenced by the a) land holding size, b) land category, c) and the seasons. However, despite these, there was still a difference between the expected and the actual yield. Table 49 shows the difference in yield and the farmer's reason why it is so.

Table 48. Comparison of average cost of production, income, profit and seed cost before and after adoption of DLS (N=105).

| ITEM | 1982 Before Adoption of DLS1 | 1984 After Adoption of DLS At current prices | At 1982 prices2 |
|---|---|---|---|
| Total cost of production/ha | Rs. 38,565.00 | Rs. 64,172.00 | Rs. 48,453.00 |
| Gross income/ha | 70,720.00 | 87,000.00 | 65,689.00 |
| Profit/ha | 32,160.00 | 22,827.00 | 17,235.00 |
| Seed cost/ha | 11,520.00 | 32,896.00 | 24,838.00 |

1Albert, W. A. D. "Marketing of Potatoes in Sri Lanka" Working paper in in-service training institute, Peradeniya, Sri Lanka, 1984

2International Financial Statistics. Vol. 38. No. 6. June 1985.

Table 49. Yield variability and farmers' explanation for such variabilities both in Maha and Yala season (N=105).

| YIELD/REASON | SEASONS Maha | Yala | |
|---|---|---|---|
| A. Average expected yield t/ha | 15.91 | 19.37 | |
| Average achieved yield t/ha | 12.88 | 18.58 | |
| Computed chi-square values | | | 0.118** |
| b. Reasons for yield variability | FARMERS Number | Percent | |
| Undesirable weather | 93 | 88.6 | |
| Incorrect planting time | 78 | 74.2 | |
| Poor seed quality | 42 | 40.0 | |
| Pests and diseases | 28 | 26.7 | |

**Significant at .05 level.

The majority of the farmers stated that yield variability was mainly due to unpredictable weather conditions and incorrect planting time. These findings indicated the unexpected consequence of DLS adoption. For instance, seed availability enabled them to plant potatoes continuously throughout the year irrespective of prevailing weather conditions.

Changes in Seed Utilization. After adoption of DLS there were significant changes in seed utilization. Table 12 of the

preceding section summarized the use of seeds before adoption of DLS and Table 50 shows several combinations of seed utilization among the farmers after adoption of DLS. However, the main purpose of seed storage was presumably for their own use (100%). However, storage for their own use and for sale had increased from 18 farmers to 54 farmers. Fifteen farmers reported that they were able to share their own seed with other farmers. These changes implicitly elaborated the farmer's ability to manipulate the adaptive economic behavior.

Table 50. Seed utilization after the DLS adoption, ranked according to the freaquency of mention (N=105).

| SEED UTILIZATION | FARMERS | |
|---|---|---|
| | Number | Rank |
| For own use | 105 | 1 |
| For own use and sale | 54 | 2 |
| For own use and share cropping | 38 | 3 |
| For sale and share cropping | 31 | 4 |
| For sale to other farmers | 20 | 5 |
| For share cropping | 15 | 6 |
| For own use and share cropping and sale | 13 | 7 |

One of the most spectacular changes observed during the survey was the farmers' change in entrepreneurship. There were 12 farmers who operated DLS storage as a commercial enterprise for the purpose of selling seeds in the area.

Although they were not cultivating a larger area of potatoes, they continuously purchased seeds from farmers from the area or adjoining potato growing district Nuwara Eliya, at harvest time presumably at lower price and stored as seeds for sale. These seeds were stored in the DLS with a combination of traditional storage methods such as the use of old potato crates and spreading on the floor. Of the 12 farmers, four handled more than 30,000 kg of seed potatoes per year. Not only Farmers, coming from around these commercial storage facility but also farmers from far away places purchased sprouted seeds from these sources. Thus, there was a change in seed flow not only from area to area but also from district to district. This finding was similar to the findings of Rhoades (1984). The danger obtained from these free movement of seeds from area to area would be the spread of diseases particularly bacterial wilt as there was no guarantee about the quality of seeds.

Reduction in storage losses. It was reported by several researchers that storage losses which occurred before DLS adoption (Albert, 1982, Rhoades, 1984) exceeded even 25 percent of the total stored seeds. Seed potato is a costly item and any

loss would result in considerable economic loss to the farmers. It was found that storage losses due to pathological, physical and physiological reasons were reduced to a considerable level after adoption of DLS. Although assessments of quantitative losses attributed to each reason were difficult, it seemed that the relative overall losses due to these reasons were very much less than before the adoption of DLS.

Table 51 indicates that 82 percent of the farmers had less than 12 percent storage losses while only 10 percent of the farmers reported that losses were still higher than 15 percent and above after 6-7 months of storage period. The dramatic decline in seed losses was possible due to improved storage practices and the adoption of DLS.

Table 51. Percentage losses in the DLS storage due to pathological, physical and physiological reasons (N=105).

| PERCENTAGE LOSS | NUMBER | PERCENT |
|---|---|---|
| Less than 10% | 47 | 44.76 |
| 11 - 12% | 39 | 37.14 |
| 13 - 14% | 8 | 7.62 |
| 15 and above | 11 | 10.48 |
| Total | 105 | 100.0 |

Change in labor and time involvement. The study revealed that there was a significant change in the total labour and time involvement in storage activities after the adoption of DLS. Time and labour involvement in storage activities were reduced as compared to previous storage methods (Table 52).

Table 52. Time and labour involvement in DLS practices as compared to previous activities (N=105).

| ITEM | EQUAL | | MORE | | LESS | | TOTAL |
|---|---|---|---|---|---|---|---|
| | No. | Percent | No. | Percent | No. | Percent | |
| Time involvement | 1 | 0.75 | 17 | 16.19 | 87 | 82.85 | 105 |
| Labour involvement | 0 | 0 | 22 | 20.95 | 83 | 79.04 | 105 |

# CHAPTER V

# SUMMARY, IMPLICATIONS AND SUGGESTION FOR FURTHER STUDY

## Summary

This study examined the processes involved in the adoption and diffusion of the Diffused Light Potato Storage technology (DLS) and its agro-socioeconomic impact on potato farming in the Badulla district in Sri Lanka. The specific objectives were: (1) to determine the process involved in the development, adoption and diffusion of DLS technology; (2) to analyze the interactions between and among farmers, researchers and extension agents in the process of development, diffusion and adoption of DLS technology; and (3) to find out the impact of DLS technology in the potato production system in terms of agro-socioeconomic aspects.

The study was conducted in ten agricultural service center areas in the upper part of Badulla district. These areas were selected since 50 percent of the total potato production of Sri Lanka is concentrated in these area and also because more than 900 farmers adopted DLS technology since its introduction in 1979.

The methodologies used in gathering the information were interview schedules, ethnological observations, inspection of records and informal interviews. The sample consisted of 105 farmer adopters, 30 non-adopter farmers, 30 extension agents and 3 research personnel. The data was statistically analyzed to obtain frequencies, averages, percentages and ranks. The correlation and associations were analyzed using chi-square test. The Logit model was used to assess the DLS adoption probabilities of farmers.

### Socio-economic Environment of Farmer Adopters

The average family size of farmer adopters was 5.3. Of the 105 farmer adopters 101 were males and four were females. The average age of the farmer adopters was 43.3 years while the range was 20-70 years.

The farmer adopters' educational attainment ranged from no schooling to university level. On the average, farmers had 6.5 years of formal schooling. Six farmers had vocational training on agriculture.

Of the farmer adopters, 94 reported farming as their main occupation. Their average years of experience in potato cultivation was 16.8.

All the farmers owned lowlands, highlands homestead and Chena lands. The average land size owned by a farmer was 1.4 ha and all the farmers were classified as small farmers.

All the farmer adopters grew one crop of rice and two crops of potato per year before adoption of DLS. Other vegetable crops in the cropping system were cabbage, beans, pumpkin, sweet potato and radish.

Cost of production of potato per hectare in the Maha season was Rs 65,904.23 and in Yala season, Rs 62,441.60.

Of the total cost of production 51 percent was for seed materials, 22 percent for other inputs, 11 percent for hired labor, while 16 percent was the inputed cost for family labor. Net profit for Yala season per hectare of potato was Rs 27,500.00, 31 percent higher than the Maha season. It was found that potato crop demands the highest capital investment and accrued the highest income as compared to other vegetable crops in the cropping system.

## Storage of Seed Potato and Utilization

The majority of the farmer adopters stored seeds for their own use (88%) even before adoption of DLS. Most widely used traditional storage methods were keeping seeds in old potato crates, spreading on the floor and keeping in attic and under beds. Sixty five percent of farmer adopters reported storage problems, which were storage losses dur to rotting, weak sprout growth, shorter storage period and tuber moth damage. The seed losses were more than 27 percent of the stored potatoes. Among the seed sources, government farmers were the most commonly preferred seed source.

There was a great change in seed storage practices, seed utilization and seed purchase after adoption of DLS. However, 85 percent of the farmer adopters still used the traditional storage practices simultaneously with DLS. The reported purposes of seed storage after adoption of DLS were for own planting (100%) and for sale (33%).

All the family members participated in various seed storage practices. More than 82 percent of the farm family units revealed that the most cumbersome activity among the seed storage practices was sorting of rotten tubers. Only 30 percent of the farmer adopters sorted seeds either once in two weeks or once a week.

## Adoption Processes of DLS Technology

The average time taken for initial adoption decision was 17.8 months with a range of 2-51 months. However, farmers who

adopted DLS late were more confident in the performance of DLS under their own setting and adopted DLS technology for full use. Three broad adoption processes were identified namely: formal adoption process, in which the five stages of the adoption process (Roger and Shoemaker, 1971) were followed sequentially; iterative adoption process in which five stages of the adoption process were not sequentially followed; and, galloping adoption process in which certain stages were omitted or not followed by farmers. The percentage of farmers who followed the formal, iterative and galloping adoption were 30, 44 and 26 percent, respectively.

The predominant factors that motivated farmers to adopt DLS were convenience of the storage, low cost, quality seed production and its suitability to their existing system.

Farmers' evaluation of DLS technology during the adoption process had led to numerous modifications of the original structures demonstrated to them. More than 72 percent of the farmers modified their storage after initial adoption. Relative advantage of DLS over traditional storage was perceived by the farmers as very high. The only highly disadvantageous reason given by farmers was insecurity of stored seeds.

During the various stages of adoption process extension agents influenced the farmers considerably and was followed by farmers.

Among the reasons given for the non-adoption of DLS were lack of security (60%) and lack of funds to construct DLS (37%). More than 43 percent of these farmers said they had enough space in the house to store seeds in the traditional way. Twenty six percent felt no serious problem in their traditional storage.

Farmer adopters attitude towards the present DLS storage showed a 13% of farmers were highly satisfied with it and 40 percent were dissatisfied with the present storage structure.

## Diffusion of DLS technology

The spatial diffusion of DLS technology within the study area was analyzed and there were three distinctive diffusion processes.

Rapid diffusion of DLS among selected group of farmers who were resource-rich and strategically located along the main road was absent and this led to the emergence of "horizontal selective" diffusion process. In this process, diffusion of DLS technology was basically from extension agents to farmers. In 1982 out of 37 farmer adopters, 60 percent were found to be under this process.

The second predominant diffusion process was "core to periphery" in which the diffusion of DLS was from core adopter farmers to neighboring farmers forming a cluster through a voluntary effort of farmers. Apparently, seven clusters of farmers involving 62 followed this type of diffusion process.

Lastly there were sporadic diffusion of DLS among isolated farmers and this "ad-hoc diffusion process" was by and large initiated by some conservative farmers. More than 20 percent of farmer adopters were involved in this adoption process. However, diffusion of DLS was not enhanced by this process.

Analysis of Interaction

Interaction among farmers were predominantly interpersonal, face-to-face and informal. All the farmers expressed that they had adequate opportunities to interact with each other and 36 percent of the farmers sought information from farmer adopters.

Farmers' communication with village leaders, key informants, officials of the cooperative store and rural development society also provided important information regarding DLS technology.

Interaction between farmers and extension agents were interpersonal and group contact and mostly initiated by extension agents (67%, 86%). Farmer adopters felt that opportunities and frequency of contact with extension agents were adequate (86%). The most preferred extension methods by farmers were personal contact and field trips.

Interaction between farmers and research personnel was found to be minimal and/or inadequate. However, farmer adopters perceived that research personnel could provide expert information on DLS (45%).

Interaction between and among farmers helped both extension agents and farmers in identifying most of the storage problems. It also helped them to improve their storage practices. Lack of attention given to the women and children as potential clients in extension activities was evident. Only 15 percent of the women and 4 percent of grown children were contacted by extension agents in their farm visits.

Interactions between extension agents and research personnel mostly took place on off-farm situations and were formal in nature. However, 50 percent of extension agents felt that they lacked opportunities to interact with research personnels. In-service training and training programs helped extension agents to interact with research personnel.

Agro-Socioeconomic Impact of DLS

Almost all of the farmers had increased the area planted to potato irrespective of land size. The minimum increase in area

was 0.18 hectares while the maximum was 0.76 hectare. Differential access to land was not an impediment to adopt DLS. The farmers increased their area planted to potato by renting (100%), using unutilized lands (40%) and by increasing the cropping sequence (71%). There was a decline in growing other vegetable crops such as cabbage, beans, tomato and radish.

The share cropping between seed-rich farmers and seed-poor farmers was increased by 14 percent. In addition, changes in potato cultivation practices such as changes in potato cultivation season (97%), staggered planting (70%) and changes in cropping pattern (40%) were observed. The overall improvement of potato crop in relation to early emergence of the crop (76%), low incidence of pest and diseases, early maturity of crop (60%) and high yields (96%) were also realized after adoption of DLS.

With regard to social impact of DLS, there were requirements in social participation (69%), relief from drudgery involved in seed handling (25%), family members involvement on seed storage (43%), changes in attitudes in bringing seed from "dark" to "light", and reducing the enormous hardship in acquiring seeds from outside sources (80%).

One of the predominant economic impacts of DLS was changes in family farm income. More than 57 percent reported they were able to increase family income by 21-40 percent, and only three farmers believed that they were unable to increase their income. However, there was no reduction in cost of production after adoption of DLS.

Twelve farmers operated DLS as commercial enterprises.

More than 82 percent of the farmers reported that they had less than 12 percent losses in seed storage after adoption of DLS.

There was a significant reduction in the total labor use and time alloted for storage activities after adoption of DLS (80%).

## Implications of the Study

Although the diffused light potato storage technology seemed advantageous and feasible under the small potato farmers' conditions, only less than 20 percent of the potential farmer adopters used the technology. Therefore, this would imply the need for diagnosis of the relevant constraints that were really responsible for low adoption. Furthermore, the development of strategies for rectifying such constraints is much needed.

The recognition of the emergence of horizontal selective diffusion of DLS among resource-rich and more accessible farmers through a skeptical extension activities strongly suggests a re-orientiation of extension strategies. This does not imply that

resource-rich, roadside farmers should be ignored but more importantly, there is a need to go beyond these farmers and approach the majority of farmers, the resource-poor farmers who reside away from the roadside, who are more often neglected.

Moreover, it was found that agriculture extension agents were conducting or organizing mostly extension programmes only for adult male farmers on the seed potato production and storage; but the women and children were the largest contributors on the seed storage activities as compared to the adult male farmers. Therefore, the regrettable ignorance of women and leaving them from the agricultural extension activities by extension agents may cause substantial impediments on the adoption of agricultural technologies which were meant for small family farms. Furthermore, the role of women and children in potato production system as equally important partners in family farming and the underreported women's contribution in storage activities by the household farmers, are significant information as basis for planning and organizing strategies for extension directed towards them.

An analysis of the interaction networks between farmers and research personnel revealed the inadequacy of interaction opportunities throughout the process of technology generation to the final diffusion of DLS. This did impede the essential farmer-researcher dialogue to a considerable extent in understanding the farmers' conditions, needs and priorities for farmer-oriented research. There is much potential opportunities for learning from farmers if these interaction links and opportunities could be strengthened by working with them and involving them in on-farm research activities.

Although the international agricultural research institution can generate technologies with a broader perspective, it is essential to establish a firm link and collaboration with regional and national research systems in order to develop technologies which are acceptable under heterogenous agro-socioeconomic environments of the farmers. Furthermore, farmers are often capable of developing their own technological innovations based on the offered technological principles. Therefore, the challenge is not only to establish a firm link and interaction networks between international, regional and national research institutions but also with the farmers in order to facilitate flow of information in both ways. Introduction of DLS technology through weak and ad-hoc link with the national research and extension network not only caused much of the confusion among the disciplines but also unexpected and not very favorable consequences. Therefore, these interactions are needed to be strengthened along the way of technology generation and dissemination so as to sustain the adopted technology and establish an effective feedback relationship between the various disciplines for productive research utilization.

The introduction of DLS and its dissemination among farmers however, had improved the quality of seed potatoes and the yield. Nevertheless, there is a need for the DLS technology to be

accompanied by other relevant technological innovations such as selection of potato seeds in the field, improved seed production practices for its optimum realization of the benefits. Unless and until such technologies are integrated into the potato production system, sustaining the DLS technology in the study area may be marginal.

Further, this study illustrates the farmers' rationality and the need for evaluating offered technological innovation under their agro-socioeconomic environment in order to fit these into their farming systems. Based on these evaluations, numerous modifications and adaptations were made to the offered technologies by farmers to generate their own technological alternatives which were more acceptable and sustainable under the prevailig farming systems. With a fair understanding of this phenomenon through a viable on-farm research approach would facilitate integration of farmers as active partners in agricultural technology generation-adoption process, rather than mere passive recipient of technological innovations.

## Suggestions for Further Study

1. A cost-benefit analysis of the DLS technology may be unertaken so as to assess the economic efficiency and viability of the technology under farmers' conditions.

2. A comparative study of the yield performances of DLS stored seeds and the seeds stored in traditional methods under farmers' conditions may be relevant to assess the quality and the potential of DLS seeds.

3. The introduction of DLS facilitated the production of seed potato requirements for planting both in Maha and Yala seasons. However, this practice may inevitably initiate rapid degeneration of the seed stocks of farmers due to prevalence of cumulative infection of viruses and bacterial diseases. It causes severe yield reduction under farmers' field conditions. Therefore, it is relevant and needed to study these problems in detail and develop strategies to overcome such problems under farmers' field conditions.

4. Farmers' participation and involvement in farm level technology generation and dissemination process are considered important component. However, to comprehend the contradictions and implications between the technological innovation-diffusion process and farmers' participation it is necessary to develop a systematic approach and methodological scheme so as to create a conducive environment for such participation. This is also a broad area for a research study.

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