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CHANGING A POST-HARVEST SYSTEM: IMPACT OF DIFFUSED LIGHT POTATO STORES IN SRI LANKA

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Abstract

This paper presents a country case study describing initial transfer and impact of a new post-harvest technology. Conditions in Sri Lanka's main potato producing regions in 1980 were conducive to rapid acceptance of low cost, diffused light storage. Due to rising costs of foreign seed, unavailability of seed at optimal planting times, heavy losses in handling and storage, government concern with foreign exchange, and extension involvement, farmers became receptive to new methods for improving existing storage practices. This initial study of adoption and impact illustrates how improved post-harvest technology can have important consequences, not only in cutting storage losses, but in raising yields, changing cropping patterns, reducing dependency on foreign seed imports, saving foreign exchange and bringing prestige to the national potato research and extension programs.

Resumen

Este documento de trabajo presenta un estudio de caso de transferencia inicial e impacto de una nueva tecnología de post-cosecha en un país. Las condiciones de las principales regiones productoras de papa en Sri Lanka, condujeron a la pronta aceptación del almacenamiento de bajo costo y luz difusa. Debido al creciente costo de la semilla foránea, la falta de disponibilidad de semilla en épocas de siembra, las grandes pérdidas en la manipulación y almacenamiento, la preocupación del gobierno por las divisas, y la participación de la extensión, los agricultores fueron receptivos hacia los nuevos métodos para mejorar las prácticas de almacenamiento existentes. Este estudio inicial de adopción e impacto ilustra como la tecnología mejorada de post-cosecha puede tener importantes consecuencias, no sólo en la disminución de las pérdidas en almacenamiento, sino también en la mejora de la productividad, el cambio de patrones de cultivo, la reducción de la dependencia en las importaciones de semilla, el ahorro de divisas y el prestigio en la investigación nacional de papa y en los programas de extensión.

CHANGING A POST-HARVEST SYSTEM: IMPACT OF DIFFUSED LIGHT POTATO STORES IN SRI LANKA*

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I. Introduction

The earth's population will increase from its present four billion people to almost seven billion in 16 years. To maintain 1984 levels of food intake, already extremely low in developing countries, food production will almost have to double. Yields must be increased by 30 per cent while 25 per cent more new agricultural land must be brought under cultivation (FAO 1981; Booth and Burton 1983: 269-270). Realizing it is highly improbable that these goals will be accomplished in such a short time, international and national agencies have added a third strategy: cutting post-harvest losses. Using the potato as an example, Booth and Burton (1983) note that if post-harvest losses could be cut by 50% in less developed countries, this would be equivalent to a 12.5% increase in yield, representing 40% of the potato's contribution to the increased food supply needed in developing countries by the year 2000.

Despite increasing worldwide attention given to post-harvest research and development, little effort has been made to document if planned efforts have had a practical payoff in helping solve food problems. This paper aims to describe and analyze the adoption and impact of improved, low cost potato storage management practices in Sri Lanka, a developing country that has officially recognized the importance of the post-harvest sector (Daily News 1983).

II. Policy Background

Although English planters had grown potatoes in home gardens in Sri Lanka as early as 1850, only in the mid-1950's were

* A special thanks must be given to Mr. W.D. Albert of the Sri Lankan Ministry of Agriculture who has been a driving force behind the success of diffused light storage in Sri Lanka. He kindly assisted in the organization of this follow-up study. Also, the study would not have been possible without the assistance of Mr. M.B. Agalawatte, economist with the Ministry of Agriculture.

organized government attempts made to promote potato production (Devasabai 1982). Still by 1967 most of the 60,000 metric tons of consumer potatoes required to feed the nation were imported, mainly from Europe. However, in May 1967, a ban on importation of consumption potatoes was instituted in an effort to save foreign exchange. This strategy set the stage for promising farmers high returns on investments if they could successfully produce potatoes. Production expanded rapidly rendering potatoes as one of the main commercial vegetable crops in Badulla and Nuwara Eliya Districts (Table 1).

Table 1. Imports of consumption potatoes and extents cultivated

Year	Quantity imported (tm)	Extent cultivated (ha)	Quantity produced (tm)
1965	74,873.9	804.5	4,730.4
1967	18,425.8	1,353.7	11,531.1
1969	—	2,968.4	26,979.2
1975	—	3,121.8	27,978.3
1977	—	3,097.9	29,153.4
1979	—	4,038.4	46,942.0
1980	—	5,214.5	64,767.8

2.471 acreage = 1 ha
1 cwts = 50.9 kg

Source: Albert, n.d.

Since the late 1960's potato production in Sri Lanka has been strongly influenced by the interplay of two countervailing factors: (1) regular shortage of quality domestic seed and dependence on imported seed, and (2) Sri Lankan government's desire to reduce foreign exchange expenditures through reducing imports of seed potatoes.

To address the seed problem the government has attempted to produce domestic requirements on government farms. After several unsuccessful experiences during the late 1950's, the government resumed imports of disease free tubers in 1965 for direct sale to farmers. Nevertheless, a campaign has continued to cut seed imports as had been done with consumer potatoes. In the early 1970s, a scientist from the International Potato Center visited Sri Lanka and noted:

> The government of Sri Lanka has issued a 10 year warning that potato seed imports will be gradually

> decreased from current levels of about 5,000 tons to near zero. <u>This will be possible only if the farm storage of seed has a sound technological base</u> (Niederhauser n. d. emphasis added).

By 1980, the government had stepped up its efforts to cut imports to the minimum by adopting a three point program:

1. Development and support of a tuber seed multiplication program wherein government farms and growers produce the national requirement;

2. utilization of true or botanical potato seed as an alternative to tuber or vegetative reproduction;

3. improved storage conditions.

Regarding the third point, The International Potato Center and potato specialists in the Sri Lanka Department of Agriculture have collaborated since late 1979 to seek appropriate solutions for post-harvest problems in Sri Lanka potato production. As a result of this collaboration, an estimated 2000 Sri Lankan farmers have improved their storage systems. The adopted technology known as diffused light potato storage, continues to spread rapidly and offers one approach in helping reduce the nation's dependency on imported seed. An understanding of how and why this new post-harvest system is being adopted and its impact is relevant to countries and programs interested in solving post-harvest problems.

III. <u>Diffused Light Storage and Introduction to Sri Lanka</u>

The diffuse light storage (DLS) technique is based on the use of natural indirect light instead of low temperature to control excessive sprout growth and associated storage losses. The principle that light reduces potato sprout growth has long been established in the scientific literature (Dinkel 1963), although its practical use was not known to science until recently. Some farmers in developing countries have independently used indirect light as a storage technique and formerly, in some European potato producing countries, it was commonly employed in pre-sprouting treatments prior to planting.

The International Potato Center in Peru has resurrected the technology and adapted its use for potato farmers in a wide range of environmental conditions in developing countries. CIP biological scientists working closely with anthropologists from CIPs Social Science Department realized the need for and thus sought a simple, low cost technology which could make a visible difference in production and be readily adopted by farmers. The guiding philosophy of CIP's "Farmer-Back-to-Farmer" approach was to gear the technology as closely as possible to the farmers' needs and pocketbook (Rhoades and Booth 1982).

In 1979, a Sri Lankan scientist, W.D. Albert, received training in the DLS technology and CIP's post-harvest philosophy in the Philippines. Upon return from the Philippines, Albert held discussions with extension workers from the main potato producing districts of Badulla and Nuwara Eliya. At this time farmers were attempting to store their own seed due to costs and difficulty of obtaining imported seed at proper planting times. Four experimental stores on four government farms were established in order to compare traditional practices of dark storage in crates or under beds with the diffused light technique, (e.g. see Table 2 for results of one representative trial).

Albert returned to the Philippines in the mid-1980s for 3 months of advanced practical storage training. On a second storage course, held in the Philippines in 1981, Mr. Somarathne of the Sri Lanka extension service was exposed to the same DLS technology being rapidly adopted by Philippine potato farmers (see Rhoades et al. 1979-1983). Upon his return to Sri Lanka Somarathne assisted in setting up 16 experimental on-farm demonstration stores (10 in Badulla, 6 in Nuwara Eliya) similar to those developed by CIP in Peru and elsewhere.

Table 2. Comparison of diffused light vs dark storage of seed potatoes. Station: Meepilimana, Nuwara Eliya District, 1980-1981.

	Storage System	
	Dark	Diffused Light
Variety	Desiree	Desiree
Qnty. Stored	500 kg.	500 kg.
% Loss during storage	29%	10.9%
Qnty. Planted	355 kg.	446 kg.
Total yield	2665 kg.	4899 kg.

* These results clearly indicate that seed potatoes could be successfully stored for periods up to 7 months without appreciable storage losses in diffused light and that the field performance of potatoes stored under such conditions is significantly superior to those stored in dark. Results provided by W. D. Albert.

The basic CIP demonstration model tested in developing countries consists of a simple building with an insulated roof and transparent walls, incorporating facilities for adequate natural ventilation. In smaller units (1-5 mts.^{3}) the tubers are stored in thin layers on a series of slatted shelves and in larger units (5-15 mts.) in thin layers in stacked seed trays. Specific designs are tailored to local needs, conditions and available building materials. In the Philippines, for example, the small demonstration units were built with rough round timber or bamboo poles with shelves made of thin bamboo strips. The roof is of local thatch and the walls a combination of corrugated plastic sheets and insect/fly screen. The experimental and demonstration stores of Sri Lanka were very similar to those developed in the Philippines. However, as will be shown later, farmers rarely copy the demonstration model but adapt the principle of using diffused light to their own specific conditions and storage needs.

In 1981 extension workers in Sri Lanka's main potato producing zones started farmer training classes and held one day courses in seed production and storage. The storage work was also linked up with the Training and Visit Extension System. For each season, extension agents had to work out a program indicating "stress points" and "targets." During this season the Regional Technical Working Group declared seed potatoes a stress point, so extension agents of the Training an Visit system programmed themselves to work in seed improvement, involving the storage element.

Farmers' receptivity to the new storage technology increased in 1979 due to difficulties in obtaining seed and government policy to stop importation from Australia. The farmers had to fall back on their own seed from earlier harvests or secure from other farmers or the government. Storage thus became a crucial link between seasons, especially when farmers produced their own seed. Table 3 illustrates the expansion of national production of seed potatoes as a result of import policy change and the national seed multiplication program. Of the approximately 12,000 ton national seed requirement in '82/83, 3,000-3,500 tons were imported while government farms produced 1,500 tons.

Table 3. Sri Lanka seed requirements and production

Year	Seed Requirement	Quantity Produced by Local Farmers	Balance Imported & Farm Produce
1979/80	10,500 t	4,500 t	6,000
1980/81	11,400 t	5,100 t	6,300
1981/82	12,000 t	5,700 t	6,300
1982/83	12,000 t	7,500 t	4,500

IV. Potato Production in Sri Lanka

A general understanding of the production system and land use patterns is necessary for analyzing the role of storage and impact of DLS on production and farmer strategies. Potato production in Sri Lanka appears at first glance to be extremely complicated. Potatoes are grown in different months in distinct agro-ecological zones of three main districts: (1) Jaffna on the northern coast (3 m), (2) Badulla of the "upcountry" dry zones (1,259 m); and (3) Nuwara Eliya in the upcountry, wet zone (1900 m). See Map 1.

DLS was introduced only into Badulla and Nuwara Eliya which account for 80 per cent of the potato hectareage and 89 per cent of national production. Badulla and Nuwara Eliya have two main production seasons called maha and yala. (See Diagrams 1 and 2.). Yala refers to the Southwest monsoon which lasts from mid-May to mid-September. Maha refers to the Northeast monsoon which lasts from October to mid-January. The maha and yala potato seasons of Badulla occur in different months than maha and yala of Nuwara Eliya.

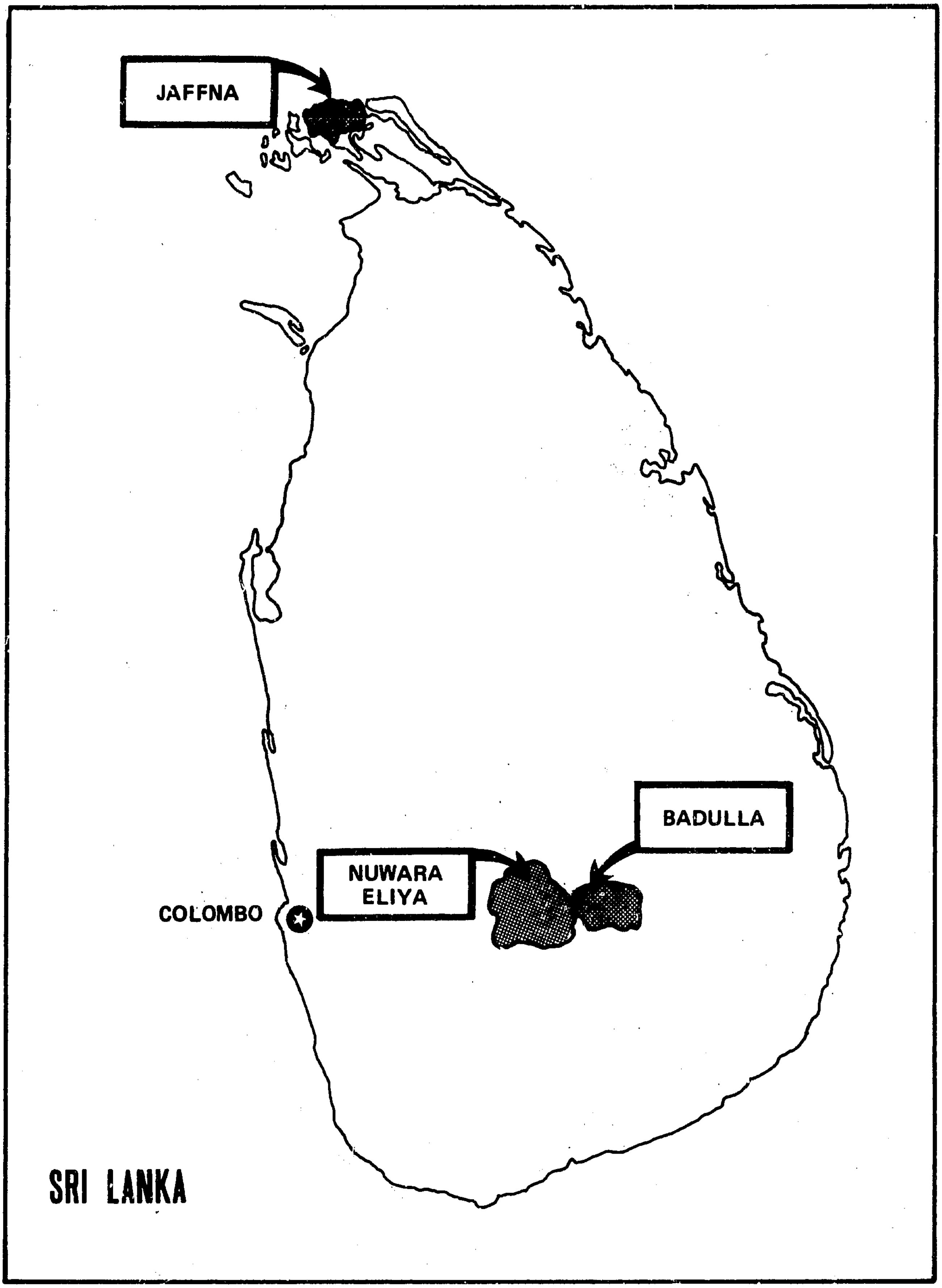
In Badulla, maha planting occurs mainly in an upland zone called chena while yala planting is confined to the paddy lowlands. The maha planting uses primarily imported seed which is multiplied for planting at yala in the paddy zone. Nuwara Eliya is located in a higher, cooler, and more humid zone than Badulla. It is fundamentally a vegetable production zone for the Colombo market as well as the main seed potato production area. Government seed farms are also located in this district. In addition to the major season crops, small amounts are grown throughout the year.

Until 1979, the government allowed importation of foreign seed for both maha and yala. The seed for maha season comes mainly from the Netherlands, although West Germany, Denmark, and Scotland also export seed to Sri Lanka.

Approximately 1,300 tons of seed were imported annually from Australia for yala, especially in Badulla District. Due to difficulties in obtaining seed and government targets of reducing imports, a decision was reached in 1979 to stop the Australian importation for yala. The only importation allowed now is for the maha season.

V. Farmer Response and Storage Adaptations

To understand farmer response to the new pressures following the ban on importation for yala and toward diffused light storage, an anthropological study was conducted in



Map 1. Main Potato Production Zones: Badulla, Nuwara Eliya, and Jaffna.

POTATO CROPPING CYCLES
SRI LANKA
(1983)

Diagram 1

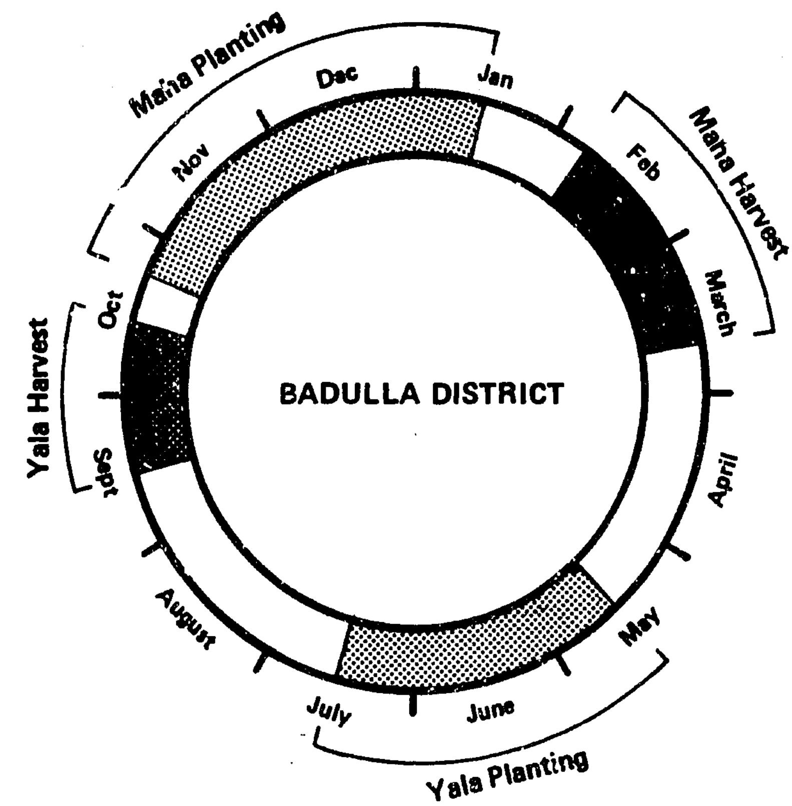
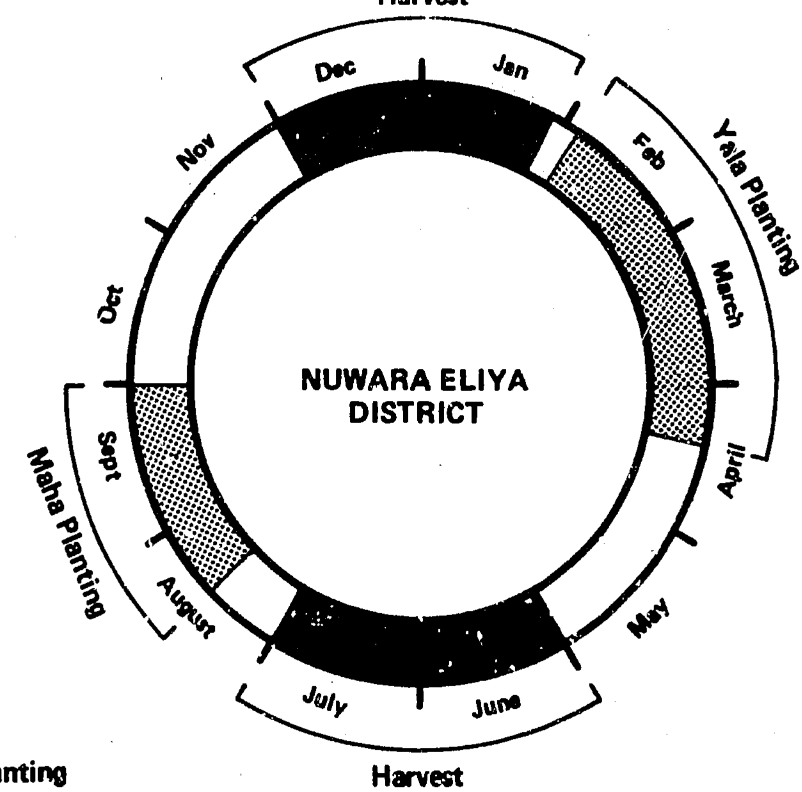


Diagram 2



Planting

Harvesting

September, 1983, in collaboration with the Sri Lanka potato program (see Rhoades 1982 for a description of the methods used). This informal survey was carried out in Badulla and Eliya Nuwara Districts. Ethnographic, open ended interviewing was utilized. Forty three farmers were interviewed as well as extension and research officers responsible for the transfer.

No reliable statistics exist on the number of total adopters or degree of adoption. According to Mr. Ananda de Silva (1983) of the extension service, from 1979 to 1983 over 500 diffused light stores were built in Badulla and Nuwara Eliya Districts on the recommendation of the Department of Agriculture. He further estimates that two thousand farmers, while not building new stores, have modified their storage system to a satisfactory level. Fortunately, some extension offices have lists of farmers who have made changes. These lists are developed from the government incentive plan of allowing farmers to buy an extra crate of imported seed if they make improvements in their stores. In Welimada segment (1964 hectares) of Badulla District alone, 427 farmers according to this list had made changes by 1983. In Nuwara Eliya, a reported 125 farmers have built stores. With at least 600 stores to be financed by the end of 1983, we can estimate that between 1200 and 2000 farmers have made changes in their seed potato storage system to allow or the use of diffused light. Until more reliable data are available, even this remains a guess.

The pattern of adoption/adaptation in Sri Lanka is strikingly similar to that observed in other countries where DLS technology has been introduced and diffusion has occurred (Rhoades et.al.1979, 1983). Farmers tend not to build new stores or copy demonstration stores precisely, but rather modify existing dwellings to meet their needs and budgets. Even in the few cases when new structures were built, farmers altered demonstration designs to meet their own preferences.

According to Ananda de Silva (1983), two special problems confronted farmers: (1) cold weather conditions in Nuwara Eliya, and (2) pilfering in both districts. Farmers responded by integrating diffused light stores into existing sheds, garages, and rooms attached to their houses. Many farmers built close to the kitchen or near the rear of the house, perhaps for security, or since its the most private part of the dwelling. Farmers sometimes sleep near their store to watch for thieves.

In addition, farmers are reluctant to let others see what they have in store due to the belief in "Evil Eye". If someone possessed by evil eye looks at potatoes, tubers in store may go bad or next year harvest may fail. Easy visibility of tubers is a major complaint farmers have about demonstration stores. The need for secrecy has affected store location and design leaving many stores without proper indirect light. For example, stores are sometimes placed toward the back of houses; if one side of the store happens to face the road, then this side is entirely closed off allowing no light to enter while the side away from the road will have an opening for light. In many cases, only one plastic sheet is placed in the roof, giving a poor and uneven distribution of indirect light.

Farmer constructed stores are of 4 main types: (1) in-house modification where an existing room in the house is adapted for DLS; (2) addition of special storage room attached to house, frequently blended into overhang eaves of the main house; (3) utilization of existing outdoor sheds; (4) special DLS separate from main dwelling and modelled after demonstration units.

VI. Understanding Farmer Adoption: The Case of Badulla District

The strategy of storage involves both technical and socioeconomic aspects. The adopting farmers surveyed in Badulla and Eliya Nuwara listed the following composite of technical benefits of the DLS system compared to their present methods.

1. Sprouting is reduced

2. Greater stem density

3. Less weight loss, soft rot, and dry rot

4. Earlier emergence in the field

5. Easier tuber moth control

6. Easier handling and diagnosis of storage problems.

In addition, farmers pointed out that DLS seed tubers sell for a higher price than tubers stored in darkness. Others noted that the government offered an incentive for changing storage practices by allowing farmers to purchase an extra crate of imported seed if they improved seed storage with the DLS technique.

While important, this list of positive technical and socioeconomic reasons for adopting DLS is simplistic and masks the underlying reasons for adoption which are tied to the potato production system and seed problems. Farmers are more prone to list traits, especially if an interviewer is administrating a questionnaire, than to explain the complex system in which storage decisions or technological changes are made. The dynamics of adoption within the farming system can be illustrated by examining in more detail circumstances in Badulla District.

Diagram 3. Land use pattern: Badulla District

Zone I	(5,000 ft)	CHENA	Cleared Forest Land where Maha potatoes planted. Imported seed planted in Chena. Harvested in February for use in Zone IV, paddy zone. Rainfed zone.
Zone II	(4,000 ft)	GANGODA	Homesteads. Storage units, typically part of house.
Zone III		KUMBURA	
		- Goda Kumbura	Slopes of paddy. Better potato production zone due to slope. Potatoes and other vegetables planted in Yala season. Planted in June, July, late as August.
		- Mada Kumbura	Paddy zone.

The agro-ecological transect above illustrates the typical land use pattern in Badulla District. Three agro-ecological zones are identified : (1) Chena (highlands); (2) Gangoda (homestead zone); (3) Kumbura which consists of the Goda Kumura (drained slopes of paddy zone) and Mada Kumbura (paddy zone).

Within this system, two important problems confront Badulla potato farmers: (1) constant shortage of quality seed, (2) late arrival of European seed for optimal planting time in maha and subsequent delays in farmer cooperatives and handling in Sri Lanka.

The yala potato production in kumbura zone follows paddy harvest using potato seed from the maha harvest in the chena. It starts at end of May, extending through July. Harvesting begins at end of August with the main harvest month culminating in September. Yield in the paddy zone is generally high and production is destined for the Colombo consumer potato market.

In 1979, the Australian seed importation ban for yala (paddy) planting forced farmers to expand production in the upland zone (chena) in an attempt to overcome the seed deficit for the yala paddy zone planting. Thus, farmers started storing more of their own seed in their houses or multipurpose stores, primarily between maha and yala. Losses in farmers' non-difussed light stores were estimated by interviewed farmers to be up to 25 per cent.

Optimal planting time for the maha season is between October 15 and November 15 to take advantage of the rains. If farmers have seed by October and can plant with optimal weather, the multiplication rate can be as high as 1-7 or higher. When foreign seed arrives late or not ready for planting, the multiplication rate may be only 1-3 (see table 4). Thus, a major limiting factor to higher production in maha is the timing of the availability of seed in relation to the best planting dates. Although locally produced and stored seed may not be better than imported seed, if available when conditions are right it can yield more than imported seed. Farmers sometimes do not even start cultivation until they get seed in hand due to uncertainty when imported seed will arrive or knowledge of its condition. Often imported seed arrives unsprouted since it has been recently harvested in Europe. However, numerous problems occur in Sri Lanka after imported seed arrives.

Albert (n.d.) describes the difficulties after imported seed arrives. Although he refers mainly to Jaffna, we can presume similar problems for Badulla and Nuwara Eliya.

> When a consignment arrives each crate has to be handled around 15 times before delivery to the farmers. During the last Maha season when 3350 tons were imported and when 500 tons of local seed were supplied to Jaffna, to get the potatoes to the Haputale, Namu Oya and Jaffna railway stations alone, nearly 500 wagon loads had to be loaded and unloaded. Then, to clear these consignments from the railway stations to the main distribution points over 1000 lorry loads had to be loaded. This whole operation has to be done within a period of 25 to 30 days, though not continuously. Seed potatoes are generally packed in 50 kilo crates and the consignment meant loading and unloading of 76,320 crates.

VII. Changes and Impact Related to DLS

Against the above background the low cost DLS system was introduced into Sri Lanka in early 1980. Although DLS is only in its third year of diffusion in Sri Lanka, some impact points resulting from the adoption of this technology can already be identified.

1. Alteration of seed flows

Diagram 4 below illustrates seed flows and storage patterns in Badulla District before introduction of DLS. Two importations of foreign seed were required: (1) maha planting in upland zone for seed production (2) yala planting in paddy zone for consumer potatoes. Due to ban on foreign seed importation for yala farmers were forced to expand production in the upland zone to overcome seed deficit in paddy zone.

Diagram 5 illustrates the situation after 1979 when importation of seed was allowed only for maha planting and DLS was introduced. This led to the creation of a new post-harvest system and seed flows. Due to potential for longer storage periods with DLS, farmers are now keeping seed from maha harvest (February - March) to maha planting (Oct - Dec). A new storage period centers on holding seed from the well drained paddy slopes for new March planting.

2. Increase yields

Farmers are interested in DLS since it allows them timely planting when climatic conditions are appropriate. Instead of the 1 to 3 multiplication rate farmers report from imported seed arriving late or in an improper physiological condition, survey farmers report a 1 to 7 multiplication rate, reflecting a 133% increase in yield due to availability of seed in the proper planting conditions (See Table below).

Table 4. Yield increase using DLS technology (Badulla District - Maha planting).

	Multiplication rate	t/ha	% increase
Traditional system with suboptimal planting dates	1 to 3	7.2	
DLS system utilizing optimal planting dates	1 to 7	16.8	133

Based on present yields this means increasing yields from 4.8 tons per hectare to 16.8 tons per hectare simply through having seed available when planting conditions are optimal. This does not mean that farmers' seed stored in "DLS" is superior to imported seed. If all farmers in Badulla opted for this strategy, it could mean an increase in maha production from around 20,000 metric tons to over 38,000 metric tons simply by taking advantage of proper planting times. A few

Diagram 4

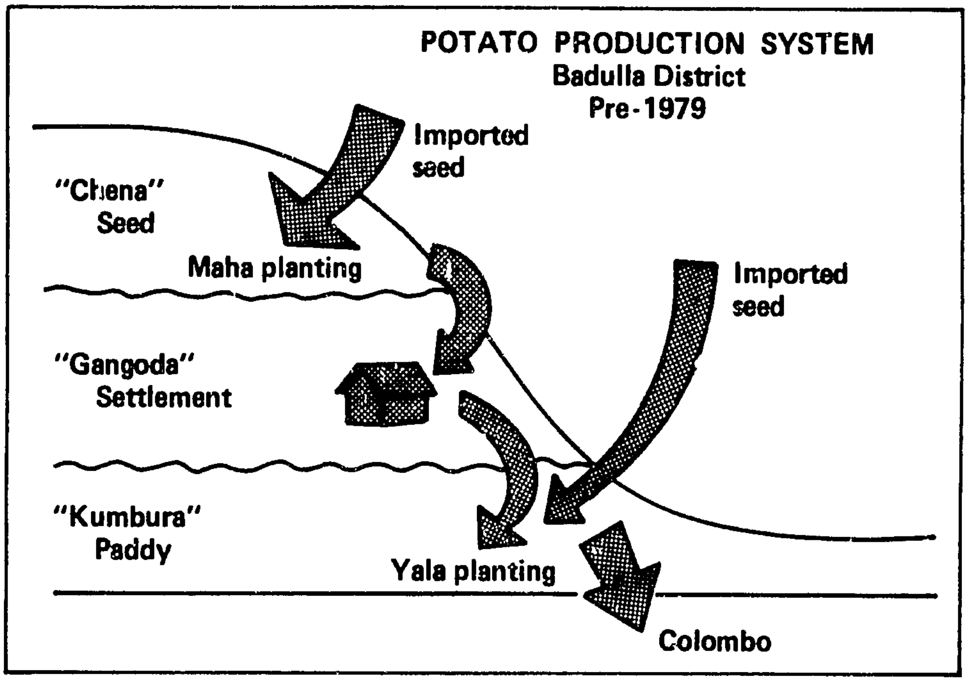
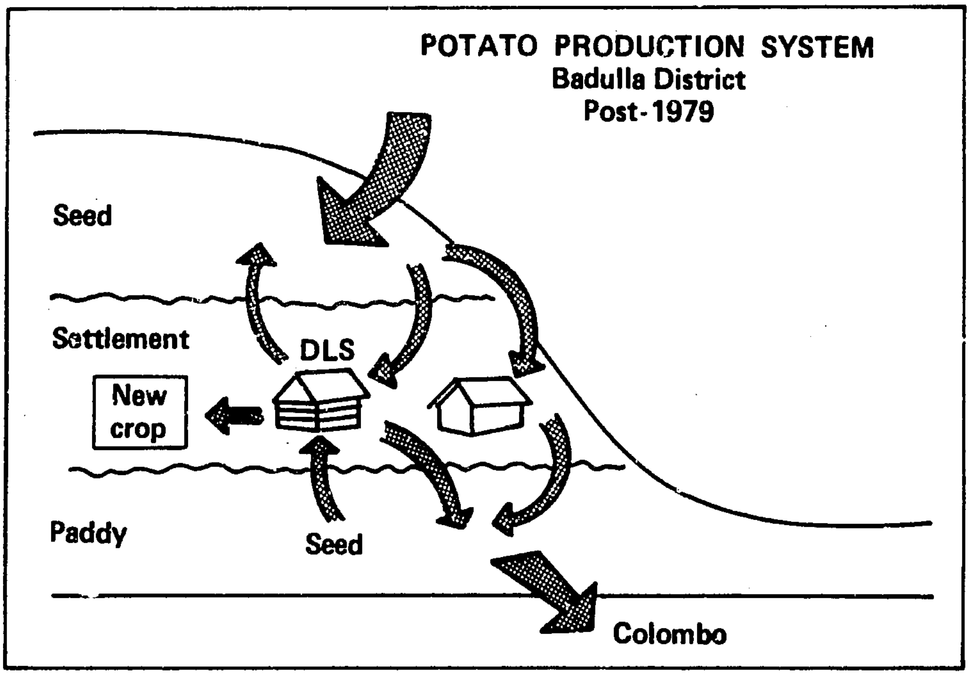


Diagram 5



farmers observed better emergence and higher yields with DLS seed, although most had difficulty in estimating amount of yield increases.

3. Reduce losses

Traditional seed storage methods for smaller farmers involve storage under the bed, in baskets, or seed crates stacked in a room of the house, sometimes close to the kitchen fire. Larger farmers tend to store in multipurpose storage buildings, but often potatoes are left in crates in dark areas. In two story houses, potatoes are sometimes stored in attic buildings where temperatures are high. Farmers complained that losses are high when stored in boxes, especially to rats, excessive sprouting, tuber moth, mealy bugs, and soft rot. Many farmers invest $80 US or more per year in tuber moth control.

During the storage periods for which DLS replaces existing practices, surveyed farmers report a 20% reduction in storage losses. Farmers pointed out that not only did greening help cut losses, especially excessive sprouting, but that management was easier since tuber moth activity can be spotted or rotting tubers quickly discarded.

4. Change cropping pattern

Two changes are possible with DLS. First, with early availability of DLS seed for a October planting, harvest could be complete by January 25. This would leave open a cropping period of 8 to 9 months in the chena zone for a new crop, perhaps leguminous, that rotates well with potatoes. Second, as illustrated in figure 5, the use of DLS makes it feasible to store seed potatoes from the well-drained paddy slopes (yala harvest) for a new March planting.

5. Reduce seed imports

Sri Lanka spends an estimated 1.5 million US$ annually on imported seed.

It would be presumptions to suggest that DLS alone could drastically reduce imports. However, as an integral part of a seed multiplication program, DLS makes it possible to theoretically cut imports within two years by 50 per cent and by 75 per cent over a longer period. This assumes DLS helps cut losses in the range of 15-20 per cent, leads to increased production, and that virus degeneration can be managed. A 50 per cent annual savings in foreign exchange expeditures on potato would be approximately 750,000 U.S. dollars, depending on the prevailing cost of seed.

Table 5. Potato imports and foreign exchange expenditures

	'77/78 MAHA	1978 YALA	'78/79 MAHA	1979 YALA	'79/80 MAHA	1980 YALA	'80/81 MAHA	'81/82 Proposed
Quantity (Tn.)	4065	1050	4157	68	3500	Nil	3351	3000
Cost (Rs.millions)	36.85	2.4	40.	.2	35	-	33	26

6. Prestige for national potato program and extension

A survey of extension workers from the potato producing zones indicated that 76 per cent feel the DLS transfer has been the most successful research-extension effort in the past 5 years. Government credit for building stores is expected in 1984 and the government has officially recognized the importance of post-harvest activity in improving agriculture (See text of inaugural speech of Mr. Gamani Jayastriya, Minister of Agriculture, Daily News; Government of Sri Lanka 1983).

VIII. Conclusions and Future Research Directions

The purpose of this paper was to present a case study describing initial transfer and impact of a new post-harvest technology. Conditions in the potato producing regions in 1980, the year DLS was introduced, were conducive to the rapid acceptance of diffused light storage. Due to rising costs of foreign seed, unavailability of seed at optimal planting times, heavy losses in handling and storage, government encouragement, and extension involvement, farmers were open to methods to improve existing storage practices.

The Sri Lankan case is internationally relevant since it illustrates that changes in the post-harvest sector can have marked and unexpected consequences for agricultural productivity and efficiency. It shows that successful post-harvest projects can render other benefits in addition to cutting losses. As a link between seasons, production zones, farmers, merchants, and consumers, storage plays many roles in farming systems and represents a development area where positive changes can have farreaching benefits. Finally, the Sri Lankan case shows how international centers, national research programs, and the World Bank training and visit extension approach can coordinate in seeking practical solutions to farm-level problems.

Despite the encouraging fact that between 1,000 and 2,000 farmers have made changes in storage practices, this study also reveals the need for continued in-depth investigation to answer unresolved questions and help solve potential problems.

1. Who are the adopters and non-adopters?

The informal survey upon which this paper is based did not attempt to compare adopters and non-adopters. Extension workers who so kindly assisted in the field research undestandably directed me toward adopters who were more influential "contact" farmers. My repeated requests to talk to non-adopters always went astray, perhaps because there were few non-adopters. However, I was able to talk to a few non-adopters who indeed turned out to be smaller, marginal producers. Smaller producers complained of no space in their houses although this may be more an excuse than a real barrier to adoption. Others argued that if you have limited land, you must sell at harvest to acquire needed cash. Farmers mentioned that to take advantage of DLS fields in both the chena and paddy zones are required.

My own observations, especially in Nuwara Eliya, suggest that adopting farmers continue to use traditional (existing) practices and DLS simultaneously. This mixing of strategies has been observed in the Philippines, Peru, Guatemala and seems to defy dichotomous thinking about adoption and non-adoption. Whether mixing of old and new strategies reflects experimentation or simply flexibility in practices is a problem for future study. Storage from maha to yala is only three months and farmers store in darkness to break dormancy. On the other hand, a few farmers are removing seed when dormancy broken and placing in diffused light. Still yet, other farmers believe in DLS even if it is for 4-5 months between maha and yala.

2. What is the Possibility of Seed Degeneration?

Farmers and researchers alike are concerned with degeneration of farmer produced and stored seed. A Diagram 5 illustrates the maha to maha storage may mean that farmers are using the same seed stock continuously in the chena zone. Farmers claim that in the first two generations, yield (1-10, 1-8) is good but by the third yield is reduced to an uneconomical level due to build up of virus diseases. For this reason, farmers continue their keen interest in disease free imported seed. Whether or not degeneration will be a serious problem, farmers already believe it will be. Therefore, continued success with DLS may hinge in part on effective seed management.

3. <u>Can the Shortage of Seed be overcome?</u>

A possible barrier to continued acceptance of DLS is the shortage of seed for the *yala* planting. Farmers mentioned that most of the *maha* planting goes for *yala* (seed requirement rarely met) leaving nothing left over to store longer. In this case, DLS may not be attractive. On the other hand, if the government does stop entirely importation of seed, those farmers with DLS will have a distinct advantage. This possibility may be reason for the government to continue rapidly the financing of DLS, especially for smaller, marginal producers.

4. <u>Is the Control of Tuber Moth and Mealy Bug a Barrier to continued adoption of DLS?</u>

Another constraint to longer storage is the incidence of tuber moth and mealy bugs. DLS can only allow storage beyond 5 months if these insect pests are controlled. Although most farmers argue that the DLS system allows for better handling, a few feel storage in indirect light encourages tuber moth. Whether the DLS system encourages increased incidence of tuber moth attack is being carefully investigated by the International Potato Center in their ongoing research.

Additionally, DLS are being built within houses or attached behind houses near the kitchen. Simultaneously, farmers are heavily using chemicals (up to $80.00/year) to control tuber moth. It might be worth considering investigating potential dangers of this pattern and seek methods to correct it if there are serious problems.

5. <u>What is the impact of DLS at the Consumer Level?</u>

The bottom line to the adoption and impact of DLS in Sri Lanka hinges on the question: will DLS make a difference in the availability and consumption of potatoes? It is obviously too early to answer this question. However, a few speculations might be in order.

In Sri Lanka, the cost of seed in Nuwara Eliya and Badulla is 42 per cent and 50 per cent of the total cost of production respectively. Theoretically, DLS allows substitution of own seed for purchased seed thereby reducing seed cost per hectare. Furthermore, DLS allows for proper planting times leading to increase yields. Those two aspects should result in reduced costs per kilo which should result in reduced price per kilo to consumer and increased consumption.

In regard to the latter, Sri Lankan economists (Suraweera and Agalawatte 1983) show that the price elasticity for potatoes is 1.2 indicating that a 10 per cent decline in price results in approximately a 12 per cent increase in sales. They conclude:

> ...the majority of especially low income potato consumer restrict their consumption to those months of the year when prices are low.

We can therefore assume that a decrease in price or leveling out of prices will signal a greater consumption of potatoes on the part of low income groups, especially in Colombo. Further research is needed to measure precisely the impact on consumption made possible through lower production costs. Continued monitoring of the technology is necessary to determine its consequences in terms of welfare and nutrition.

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