AgEnt 70-94
AgEnt Consultant Report No. 31

Enterprise Opportunities Associated with Improved Production Technologies

for

Onions, Potatoes and Tomatoes in Sri Lanka

George A. Marlowe

Horticulturist

The Agro-Enterprise Development Project
Colombo, Sri Lanka

September 1994

CONTENTS

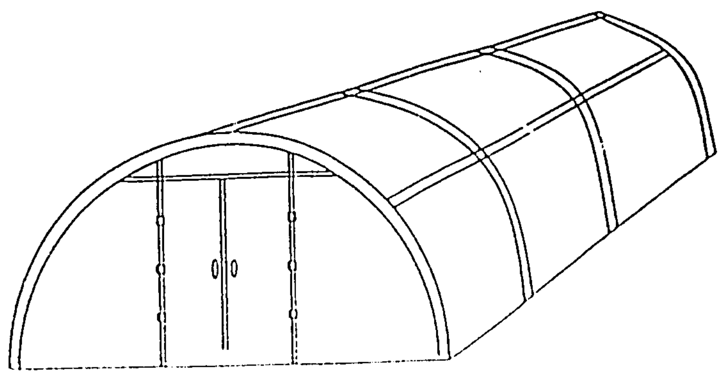
EXECUTIVE SUMMARY

The Scope of Work (SOW) encompassed assessment of onion, potato and tomato production in Sri Lanka. Major constraints were identified and corrective interventions presented. In all three crops, the technology of Containerized Seedling Production (CSP), could be useful in one or more interventions.

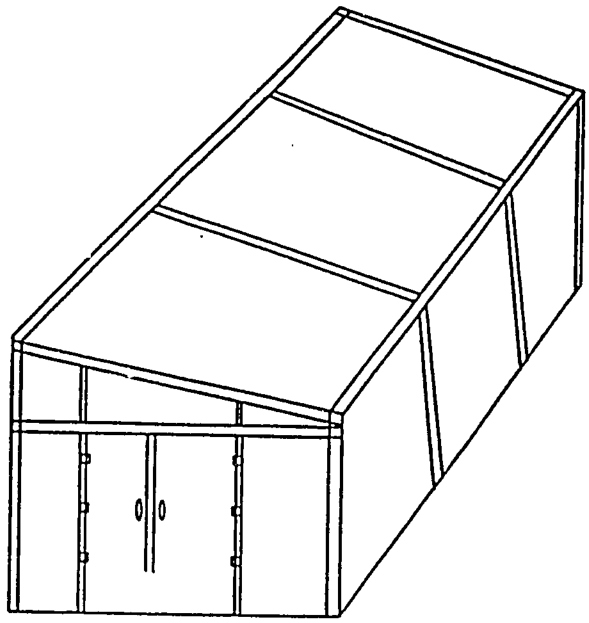
Containerized Seedling Production utilizes several very simple principles to achieve a superior transplant. The soil or soil-less material in which the seed is sown, *must* be free of all pests, be able to hold moisture, air and nutrients; and be *light in weight*, uniform and low in cost. The container in which the seedling is to be grown *must* have an opening at the bottom through which the tap root may protrude. The container *must* be suspended 50-60 cms from the ground so that air may pass freely beneath. As the tap root protrudes, the air kills the root tip. The plant responds by developing a dense fibrous root system which is the basic reason this disease free seedling is so vigorous and successful. Containerized Seedling Production has achieved global acceptance and is used throughout the vegetable, fruit, floral, nursery and forestry industry.

Containerized Seedling Production generates a multitude of enterprises. The container manufacture, soil-less material media production, specialized growers and technicians, sales and distribution are but a few. Most CSP is linked to projected structures; this generates another enterprise chain of opportunities. The real beneficiary is the farmer and ultimately the consumer because of the greater uniformity, predictability and quality of production.

Typical growing houses are found in the following illustrations:

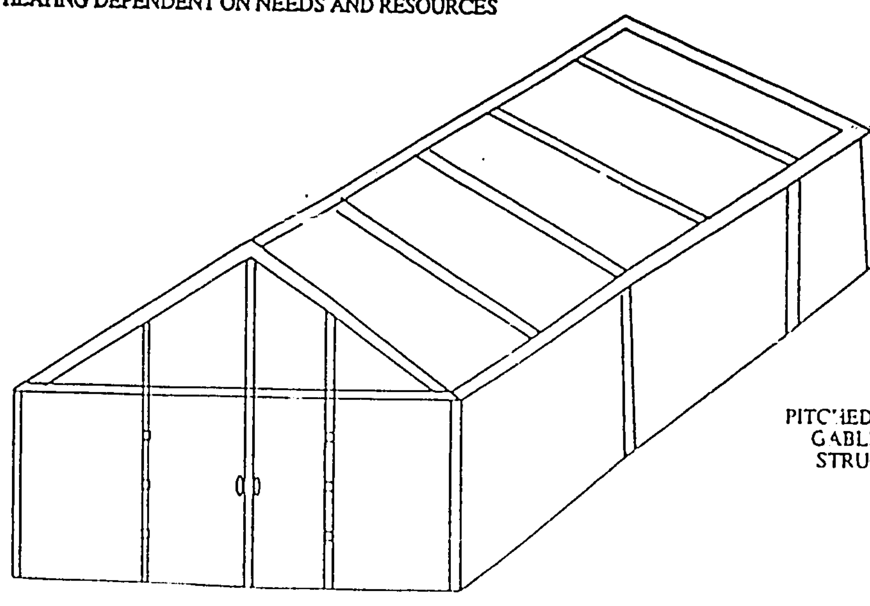


HALF CIRCLE
PIPE STRUCTURE



SIMPLE LEAN TO
WOOD OR PIPE
STRUCTURE

SIZE DEPENDENT ON NEEDS AND MATERIALS
COVERING MATERIAL POLYETHYENE, POLYETHENE
HEATING DEPENDENT ON NEEDS AND RESOURCES



PITCHED ROOF OR
GABLE ROOF
STRUCTURE

(1) Onions

Onions are one of the most popular vegetables in Sri Lanka. Production is short lived; and importation is required for 9 to 10 months annually. Onion production pivots around rice production, with major plantings (April - May) and major harvesting (August - September). AgEnt has made a valuable contribution toward extending the availability period through simple storage methods. Unfortunately, the onion quality supply compromises this storage potential, because within any seed lot a mixture of cultivars, ages of seed and maturities may be found. A reliable, ethical source of onion seed *must be* located as soon as possible.

A second crop of onions could be grown which would reduce the import period valued at 1.3 million USD, from 10 months to 2 months. The second crop nursery could be started under protection in December and harvested mid-March to early-May and stored easily until the traditional harvest provides continuity of supply. A uniform seed lot produces more uniform maturity for storage. Storage rots, shrivel and sprouting are the major causes of onion storage loss. A sprout suppressant is normally used to reduce sprouting; good storage management could help control rot and water loss. Containerized seedlings provide farmers with almost perfect field stand, more uniform growth and development, higher and earlier yields, reduced pest pressure and more profitable production.

(2) Seed Potato

Seed potato importation is valued at approximately USD 638,111 with a volume of about 6,866 mt annually. Imported seed is the most expensive input in potato production in Sri Lanka. Seed tuber quality and disease status depends on the integrity of the seed inspector of the exporting country; the care in shipping; and the methods of handling from dock to grower. Approximately 2000-2500 kg of seed stock is required to plant a hectare. Most potato growers try to grow two crops per year, but to avoid high seed costs, they often import for crop one and save seed for crop two from the first crop.

Disease free potato seed stock can be produced from true seed and micro-propagated meristem culture. Containerized Seed Production plays a vital nursery role as the tiny plantlets grow from test tube babies to young independents, to field ready transplants. This technology requires skilled personnel, simple equipment and protective structures. The methodology has global use in vegetable, floral, fruit, forestry and ornamental horticulture.

The root and foliar diseases of potatoes which could be diminished by crop rotation are only possible on the larger holdings. As storage becomes more adopted to extend the market period, tuber maturity and sprout suppressing chemicals will become more needed. Containerised Seed Production stock provides the grower greater control over variety, date of planting and harvest maturity.

(3) Tomato

Tomato production in Sri Lanka is constrained by thee major problems. Tomatoes follow the Maha rice season, produced in rice paddies during the Yala season instead of rice unless, rains are excessive. The short planting and harvest period is frequently associated with a discouraging market glut and low profits.

A technique of scheduling sowings using CSP, allows tomato growers to enjoy a series of smaller peak harvested, better use of labor, more uniform and increased profitable production. By using the character or true leaf indicator method, a grower could set as many as four different harvest maturities of transplant at his traditional planting date to achieve four different harvest peaks. This method is used to help spread product flow, is simple, low cost and very effective. In Sri Lanka protection of the CSP would be required as the transplant growing period would be done during the high rainfall period so the seedlings would be field ready as the rains subside.

Bacterial Wilt (BW)

A soil borne bacterial disease common to all members of the solanaceae plants including tomato, pepper and eggplant, is now considered one of the most crop limiting diseases in the warm, moist tropics around the world. By placing CSP disease free seedlings in a raised bed pasteurized by the sun, the grower can produce a moderately high yield before the organism re-invades the bed of soil, enters the roots vascular tissue causing the plant to wilt and die. Solar pasteurization involves covering a raised bed of moist soil with a clear plastic tarp for 3-4 weeks during the high sun period.

Sri Lankan tomato growers could increase yield, reduce crop rot and improve efficiency of pest management and picking by the use of mulch, staking and the *basket tie* method. These practices are used worldwide.

ACKNOWLEDGEMENTS

The traditional consultants report usually contains 7 to 10 pages of persons contacted, placed visited, meeting held, etc. These lists are good references, but in my case excellent field trip reports are already submitted by the two technical AgEnt Officers with whom I travelled; Mr. Phillip Mowbray and Mr. Gamini Kumarage.

Most of the major onion, potato and tomato production areas were visited, local agricultural officers were interviewed, production fields visited, and storage facilities were examined. To all of the concerned agricultural officers, farm leaders and small holders who shared their problems and accomplishments with us we are most grateful.

Meaningful conferences were held in depth with Ministry of Agriculture Research Officers at Peradeniya, Bandarawela, Sita Eliya and Mahaillupallama. The group meetings at all four locations saw immediate value for the containerized plant growing system to their individual research programs. Sri Lanka is very fortunate to have the competent and visionary leadership of Dr. S.B.D.G. Jayawardena as Research Director of Horticulture in Headquarters, Peradeniya.

On completion of my fourth short- term consultancy, I want to express my thanks to all the officers and staff of AgEnt for being so helpful and sharing. This novel approach to help agricultural industries start, grow and prosper, is one of the most defensible USAID efforts in which I have been associated in my 45 years as a professional horticulturist. Having served on numerous USAID projects, short and long term, in Asia, Africa and Middle East has given me a wide perspective from which to appreciate what AgEnt is trying to do.

I have great faith that Chief of Party Richard Hurelbrink and his staff will make this project as productive and sustainable as possible. AgEnt is a credit to USAID and American development efforts.

I. Modified Minimum Stress Production

In developed countries a profitable enterprise depends on the systematic analysis, identification and whenever possible the elimination of factors restricting profits. In developing countries the same goal prevails, but resources available often limit constraint alleviation. Minor, low cost changes in technology could help Sri Lankan vegetable growers realize more dependable, uniform and increased profitable production. To bring about some of these changes, specialized inputs may be required which are beyond the small-holders capability. To provide these new, but well tested inputs, there is great opportunity for new enterprises to develop.

These new entrepreneurs may need initial training, guidance and some financial assistance to get started. After establishment, they may need further help in the best ways to present their product, transport and market their valuable offerings. It is highly conceivable that the USAID funded AgEnt Project could provide the synergistic energy for this important development process.

Minimum stress production requires an assessment of practices and inputs from the time seed is selected until the consumer takes possession of the harvested and marketed product. In the real world, one can only expect changes gradually and must be those which convince the small holder that the advantages out-weight the disadvantages and that risks due to change are minimal; and that the new practice will be low in cost, easy to learn, and relates to his current practices in some way.

A brief assessment of the major constraints to improved vegetable production and marketing and suggestions for improved interventions should be considered.

II. Constraints Encountered

Factors inhibiting greater profitability, reliability, uniformity and development of the vegetable industry in Sri Lanka include constraints related to time, space, cost, input supply, yield and utilization of modern technology. The following list is not complete; and is offered only to illustrate how specialized business enterprises could emerge to help solve many of the problems facing small-holder vegetable growers in Sri Lanka today.

There would be very little value in listing the many problems related to marketing, import controls, etc. To show a small-holder that he would get fewer abrasions on his potatoes or tomatoes by using a smooth field crate for harvesting does little good if the availability of improved containers or there cost are beyond his control.

A. Constraints Related to Time

Most vegetable production in Sri Lanka is rainfall dependent; therefore, most vegetable production must revolve around the rice planting and harvest season; sometimes crops must be selected to fit less than ideal growing conditions, some must be hurried, delayed or omitted if a rice season is abnormal.

Many vegetables must be grown during a highly compressed season, tomatoes for example, allowing little opportunity for scheduling of production, thus causing severe market gluts in some years.

B. Constraints Related to Space

Because of small farm size there is little opportunity for crop rotation in order to interrupt pest and disease pressure. The small amount of produce generated by these rather small holdings must be effectively coalesced into larger lots in order to provide market command.

C. Constraints Related to Costs

Small-holders generally cannot enjoy economies of scale so must purchase all inputs at a relatively higher unit cost.

The high cost of seed of some crops; such as potatoes, encourages small-farmers to save their own seed which may be infected with diseases or nematodes from a previous crop.

High seed costs often encourage small growers to buy cheaper seed, which may be inferior and variable leading to erratic stands and uneven development, and lower profits.

D. Constraints Related to Yield

Low yields are generally associated with poor soil, poor soil preparation, poor seed or poor seedlings, excess or deficient soil moisture, pests or post-harvest losses. Several of the factors are beyond a small-farmers control, but the factors they can control must be managed if increased production and profit is desired.

Crop uniformity often reflects the level of care the crop has been given, the level of technology used and the influence of soil factors, eg: fertility, moisture etc. Usually, practices which increase uniformity improve yield and profitability.

E. Constraints Related to Technology

The degree of adoption of improved and traditional practices is often based on exposure and awareness, more than cost. Mulching is seldom used in Sri Lankan fresh market vegetable production; whereas, in Taiwan, Korea and Thailand the 17 known advantages of mulching are widely used to enhance production and reduce post harvest losses.

Extending shelf life and the period of marketing through storage, has not been a widely adapted practice, but offers tremendous economic potential. High temperature-high ventilation storage of onions is an example of how the availability period of onions could be extended 2 - 3 months beyond the harvest of well matured, sound bulbs.

III. Problem Solving Possibilities

The profitable production of vegetables is based on effective market oriented decisions. The minimum stress production technology is only a means of maximizing output to serve the market function. Market oriented farming is heavily based on careful planning, growing, harvesting and handling, combined with effective marketing.

Typical market oriented planning decisions include:

Disposition

What does the market want?
When does the market want the product?
How does the market want the product presented?

Execution

Do I have the best technology to grow this crop?
Do I have the right land to grow the crop; accessibility?
Do I have the right inputs to grow the crop; labor; equipment?
Do I have the right season to grow this crop?
What barriers am I likely to encounter with this crop?
Is an appropriate variety available: Seed or propagating material?

These are but a few of the many questions a successful grower must ask before the crop is initiated. The essence of minimum stress production is to provide the crop with conditions as optimal so that the grower controls the production and marketing sequence from beginning of planting to consumer acceptance.

A brief outline of some of the major problems encountered in Sri Lankan onion, potato and tomato production is listed in Table 1, along with suggested possible corrective interventions and potential business enterprizes which may develop from these interventions.

Table 1

Partial Listing or Problem Intervention and Potential Enterprise for Potatoes, Tomatoes and Onion

Crop	Problem	Possible Intervention	Potential Enterprise
POTATOES	•High cost of seed	Use of true potato seed, Meristematic seedlings and specialized B seed production.	Tissue culture laboratories, seedling producers, elite seed growers, media manufacturers.
	•Virus and nematode problems	Use of true potato seed and Meristematic seedlings.	Seedling structure builders, green house workers, field monitors, virus assay technicians.
	•Extending market availability	Use of natural temperatures - High ventilation storage. (Hill Country) use of sprout inhibitors, use of programmed monitored storage methods	Modifiers of storage, ventilation technician, storage monitors, skid and box manufacture, improved transportation.
TOMATOES	•Bacterial wilt	Solar soil pasteurization, improved varieties, raised beds disease free transplants.	Plastic film supplier, solar soil technician, seedling grower, media manufacture, container manufacture, structure construction mulch suppliers.
	•Market Glut	Scheduled plantings with staged transplants.	(Covered in above)
	•Low yield, poor stand	Use of disease free transplants, solar soil pasterilation, Use of mulches.	
	•Post harvest loss	Use of mulches, Use of staking and basket tie method, Use of improved field crates, Use of improved harvesting & handling	Mulch suppliers, stake suppliers, harvest container suppliers, modifiers of transport, improvement of collection facilities.
ONION	•Short market season, long import period	Extend availability through effective storage practices, enhance off-season production and storage.	Builders of high temperature, High ventilation store, Trained sorters, Trained storage monitors, Trained applicators of Sprout suppressant, etc.
	•Storage Losses	Develop rigid pre-storage sorting, develop effective storage monitoring, use sprout suppressants, improve harvesting and handling procedures	(covered in above)
	•Rainy period problem, for off-season production	Produce onion seedlings under cover produce onion sets	Seedling growers, Onion set growers, Media manufacture, Container manufacture, Structural Builders.

IV. Background Technology for Intervention Practices

A. Potato Interventions

1. *True Potato Seed (TPS)*

The Seed Potatoes that farmers generally plant are actually tubers, or vegetatively propagated materials. Under the proper environmental conditions, potato plants flower and form tiny *tomato-like seed balls* which contain hundreds of true botanical seeds. These seeds can be planted and nurtured to form large plants which may produce 20-30 tubers for future potato field planting.

True Potato Seed production has many advantages; most of the tuber and soil borne diseases can be avoided by using TPS produced tubers. Tuber methods currently practiced require approximately 2000-2500 kg of seed potatoes per planted hectare. From True Potato Seed only about 100-150 grams of true seed would be needed. True Potato Seed weigh about 0.5 mg and retain their longevity in good storage for 12-15 years.

The True Potato Seed method could greatly reduce seed potato importation, improve foreign exchange requirements and reduce bulk and weight in handling.

The production of TPS seed stock presents opportunities for Sri Lanka. Details of this system are presented in Appendix notation 1, for those who wish to pursue this interesting possibility further.

2. *Meristematic Production of Potato Seed Stock*

Seed tubers can be produced from small seedlings generated in test tubes. This procedure involves the removal of the tip section of plant stems or roots, placing these small pieces into a disease free both or jelly, produce favorable light, temperature and nutrients for a suitable period of time until the pieces grow into tiny plantlets with small roots and leaves. At this stage of independence, the *test tube babies* are moved into small containers and monitored carefully until ready to go into the field. From these seedlings a crop of small seed tubers can be produced. These small seed tubers can then be planted as normal tuber seeds to produce a traditional potato crop.

The advantages of tip cultured seed production are avoidance of soil and tuber borne disease, reduction in importation of seed potatoes, reduction in volume and weight in handling, similar to the positive gains experienced with true potato seed methods.

This technology is well established globally; is defensible, cost effective and valuable. Many crops including floral and ornamental crops worldwide, depend on tip culture to avoid virus diseases, reduce shipping weight, volume and costs.

Tip culture affords a challenging and rewarding enterprise opportunity for the Sri Lankan interested in performing this vital service. Further details of this technology are presented in Appendix notation 2.

3. *Specialized "B" Seed*

Most Sri Lankan potato growers prefer to plant whole small seed tubers rather than seed pieces cut from larger tubers as in commonly done in the western potato producing areas. There are advantages to both systems, but the reason developed countries avoid small seed, often called B size, is that virus laden plans usually produce mostly small tubers.

There is a challenging enterprise opportunity for Sri Lankans who arc willing to become Elite Growers of B size seed. Isolation would be required, 5-10 miles form other potato production, careful monitoring of the growing seed crop would be needed and adequate cool, well ventilated storage would be required to hold the seed stock until sold.

The source of clean disease free stock could come from TPS, Tip cultured or Foreign elite seed. The production of Elite B seed would be a serious responsibility for an entrepreneur who wished to join this specialized form of agriculture.

4. *Use of High Ventilation, Natural Hill Country Temperature and Potato Storage*

In the hill country of Sri Lanka, where most of the potato production occurs, the market period could be extended significantly by utilizing proper storage techniques. In most of the developed world, sprout suppressing chemicals are sprayed on the growing crop approximately two weeks before harvest. One popular sprout inhibitor, Maleic Hydrazide, prevents tuber sprout development for 2-3 months.

Sprouting, shrivel and rot are the main causes of loss in potato storage. Careful screening of potatoes going into storage, careful handling to prevent bruizing will reduce rot and decay. High ventilation of the naturally cool moist air of the hill country would reduce tuber moisture loss and shrivelling.

The technology is available to make extended marketing of potatoes and attractive and profitable enterprise, by utilizing several natural components, careful husbandry and the well accepted sprout suppressant.

B. Tomato Interventions

1. *Management of Bacterial Wilt*

Bacterial Wilt is a soil borne bacterial disease of serious consequence throughout the warm production regions of the world. In some area of the world, tomatoes and its relatives, peppers, potatoes and eggplant can not be produced without expensive and extensive soil treatment. The organism is a water-moved, root and below ground stem invader which clogs up the vascular tissue and causes the crop plant to wilt. ***Pseudomonas solanacearum***, cannot survive hot, dry conditions. It must have abundant soil moisture and a host plant, crop or weed , to continue its life cycle.

Suggestions for the field management of this serious problem are presented in Appendix notation 3. Solar soil pasteurization utilizes the heating power of the sun to rid the soil or soil borne insects, diseases, weeds and nematodes.

For solar pasteurization to become adopted, plastic film distribution must be available. For the production of disease free tomato seedlings there would be many challenging and profitable business enterprise opportunities for containerized plant growers, seedling structure manufacturers, container suppliers and solar soil pasteurization specialists.

2. Production of Disease Free Tomato Transplants

Seedlings grown in outdoor plant beds can be very suitable for profitable tomato production, but frequently the outdoor plants are exposed to excessive rain, wind and pest pressure. When removed from the soil bed, small roots are broken causing transplant shock and exposure to disease or other determinal organisms in the soil.

An alternative to outdoor soil beds is Containerized Seedling Production. This well accepted system is used worldwide for a great many vegetable, floral, ornamental and tree seedlings. The system involves the use of elevated containers, sterile soil or soil-like materials, and easy removal of the seedlings from the container without any damage to the fine root lets. When the tiny tap toot extend down through the bottom hole of the container, pot, tray or cone; it is killed by the air; creating air-pruning, forcing the seedling to produce a dense concentration of fibrous roots inside the container. This dense root ball increases field survival, ensures a good stand, enhances performance and eliminates re-planting. By beginning with disease free and vigorous seedlings, the farmer increases his potential crop profitability significantly.

Containerized Seedling Production enhances micro propagation, true potato seed production and nearly all vegetable production schemes. The enterprise opportunities within the CSP system are almost too numerous to mention. For example, in the United States, nearly all vegetable, flower and ornamental shrubs are grown by this method. Forestry seedlings now insure almost complete stands in one operation for reforestation operations.

There would be need for media manufacture; container suppliers, protected structure builders, seedling growers and sales persons just to mention a few of the core enterprizes. The accelerator and multiplier enterprizes such as transportation, advertising and training are but a few of the spin-off businesses that accompany this important innovative technology.

Details of the Containerized Seedling Production are presented in Appendix notation 4. Methods for disinfestation of soil and soil less media for CPS are reflected in Appendix notation 5.

3. Using Mulching, Staking and Tying

There are 17 advantages for mulching in tomato production. Most notable is the uniform soil temperature and moisture it provides, in addition to better use of fertilizer, elimination of weeds, moisture conservation and protection of fruit from soil rot.

Perhaps the earliest mulch in farming history was the straw from grain crops, and this practice is still used on many vegetables in the SE Asian region. Black plastic film is a fairly modern practice for mulching, developed in America in about 1950. Film mulch is easier to apply than organic mulch but both do about the same things.

Supporting tomatoes on stakes or wires is also an old practice. *Staking* increases pest control efficiency, reduces soil rot of fruit and makes picking much easier. The old method of tying the plant to a stake has been largely replaced with Basketing. In this method the typing material, jute, cotton or polyethylene Twine is tied to the stake but only encircles the plant loosely between the stakes.

If these profit enhancing practices become popular in Sri Lanka there would be enterprise opportunities for suppliers of mulch film, stakes and twine materials.

4. Reducing Market Glut

Methods to reduce market glut are available. In Sri Lanka the CPS system would be an important part of the protocol. This methodology is presented in detail in Appendix notation 6.

C. ONION INTERVENTIONS

1. Extending Availability Through Planting Dates

At the present time, most bulb onions produced in Sri Lanka are seeded in late June and early July; transplanted to the growing field in August, and harvested late August and most of September. They may be sold immediately if the price is favorable or held for 3 to 4 weeks by the farmer or buyer until the price improves.

The current import period extends from approximately October until late August when Sri Lanka begins its traditional harvest period.

By using CPS methods, onions could be sown under protection in mid-to-late-December, transplanted to the field in January (mid to late) and harvested mid-March to early-May. With improved storage, onions could be available until the traditional spring planted onions are harvested. This period of production would be called *off-season*, but it is really the more correct planting period for onions based upon day lengths.

Onions in Sri Lanka form bulbs as soon as the young plants forms 7-9 leaves, the off-season bulbs could be expected to produce 12 to 15 leaves in a much larger more mature bulb. Bulb size can be regulated with crowding and closer plant spacing. A diagram of this planting and harvest array is presented in the Appendix notation 6. The adoption of a two-season onion planting system would reduce importation, thus saving Sri Lanka many foreign exchange expenditures. With planning the bulb import period could be reduced from 10 to as few as 2 + months !

The enterprise possibilities would be linked to CPS improved storages for onions, and changes in onion distribution.

2. Extending Availability Through Improved Onion Storage Practices

The AgEnt Project has taken an active role to demonstrate to onion farmers that simple storage structures could extend this market period 2.0-2.5 months. To add to this very worthwhile effort a few additional technical suggestions have been presented.

3. Improving Onion Planting Stands

Onions immediately after harvest have a normal *rest period* of about four weeks before they begin to extend their inner leaves and form new roots on their short stem base. This is called sprouting and generally makes the bulbs un-marketable.

A sprout suppressant growth regulating chemical spray applied 14-17 days before harvest, while leaves are still green, will prevent this natural development. In fact, these treated bulbs cannot be used to produce seed. Sprouting, shrinkage and rots are the major causes of onion storage loss.

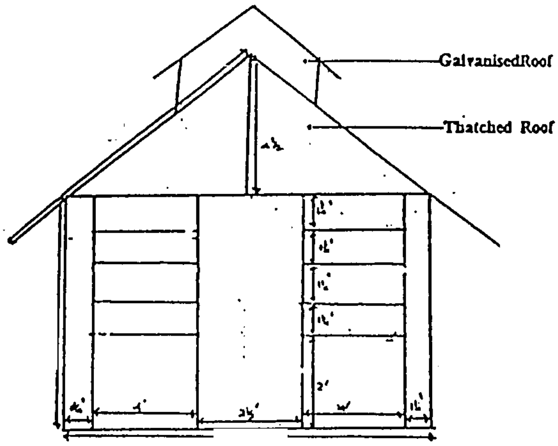
Onions can be stored at low temperature 0^0 to 5^0 for almost one year if suppressed, sound and mature. High temperature storage is almost as good and requires only some appropriate technology in addition to the 30^0 - 35^0 C storage. High temperature must be accompanied with *good ventilation air movement.*

A flat black, sheet metal over-roof on top of the proposed storage shed is a proven intervention to help promote air movement through the onion storage shelves using the physical principle that black absorbs heat and that hot air rises. This metal over-roof serves as a thermal, solar siphon.

As this storage concept becomes adopted several enterprize opportunities will develop, in the area of storage shed construction, supply of over-roof sections and construction of shelves, etc. An illustrated drawing is given below.

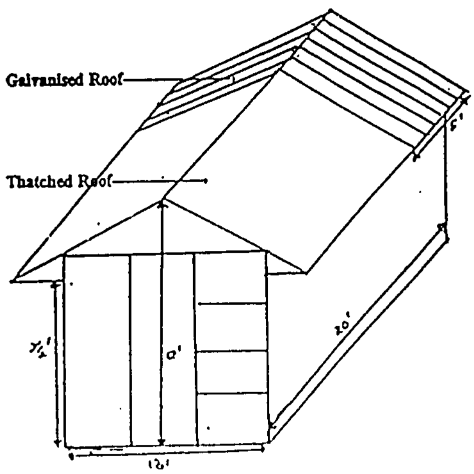
In brief, each of these interventions has potential enterprize development potential. Some of the pathways to improvement will help make Sri Lanka less dependent on imports; some will provide consumers a more reliable supply of better quality produce; but all of these proven technologies should help the vegetable growers on the island to have more successful and profitable farm operations.

TYPES OF ONION STORAGE BUILDINGS



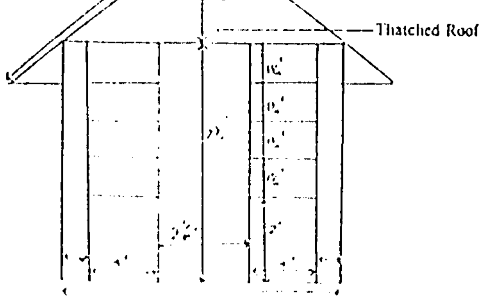
TYPE 'B'

Proposed Big Onion Stores for storing of approximately 5 M. Tons.



TYPE 'C'

Proposed Big Onion Stores for storing of approximately 5 M.Tons.



Appendix

The core of this report addresses the broad issues problems facing Sri Lanka's potato, onion and tomato growers and suggests some possible interventions for consideration and implementation . Core material is usually general, with specifics reserved for an appended collection for those who wish to explore each proposed intervention in greater detail.

It is very fortunate that the Ministry of Agriculture has already worked out much of the protocol for True Potato Seed (TPS) and tip-culture, and has extended this technology out to some farmers, and offers to train technicians for entrepreneurs to help make this much needed intervention spread.

Appendix Notation 1

PROPAGATION OF TRUE POTATO SEED (TPS)

Potatoes, Tomatoes, Peppers and Eggplant are related. The fruit ball formed on the potato after flowering looks like a small green tomato fruit. Within this seed ball there may be several hundred tiny seeds which can be used to produce plants. That can be grown to produce the traditional vegetative storage tubers used for table stock, processing, or be planted whole, or cut into seed pieces.

When a potato grower usually refers to his small 35-60 gram seed stock, these are actually vegetative propagation materials used for planting but this is not actually seed, in the true sense. Only the fine greenish-black roundish (weighing about one half of a milligram, 2000 seeds per gram) are really True Potato Seeds (TPS).

The advantages of producing seed pieces from True Seed Propagation are very important for the following reasons:

1. The seed pieces method requires about 2.5 metric tons to plant 1 hectare of potatoes; the True Potato Seed (TPS) method requires only 100-150 grams of tiny seed.

2. True Potato Seed has a viability and longevity of approximately fifteen years if stored properly; Tubers for vegetative seed can be kept only 12-15 months.

3. The spread of soil borne and many tuber borne diseases can be avoided by the use of true seed.

4. In general, potato virus x, virus y, and leaf roll viruses can be avoided by the use of the TPS method.

The great savings in bulk and wight, long storage potential and avoidance of several very serious diseases have made TPS technology important during the past decade.

The disadvantages are:

1. An appropriate cultivar, adaptable to Sri Lanka which produces satisfactory seed balls from which true seed may be taken has to be selected. An alternative to producing seed balls in Sri Lanka would be to import the suitable seed from a more adaptable seed producing country such as Peru, or other high altitude short day or whatever what particular cultivar requires to flower and set fruit.

2. The germination of true seed requires a carefully monitored seedling production period. It is in this critical stage that the seedling production in containers is very helpful. From these tiny plants with a very healthy root system survival is much improved.

3. Usually these transplants are allowed to produce small storage tubers the first season, or year and then these small tubers planted to produce a commercial crop of potatoes. This method is more time consuming than the traditional tuber seed planting system.

4. Tubers from TPS are usually more variable in shape, color and cooking quality than tubers grown from seed tubers.

5. The tubers from TPS are usually lower in yield and smaller in size than from seed tuber planting.

For Sri Lanka, TPS has great potential to reduce the cost of importing of bulky seed tubers, save foreign exchange and provide growers with disease free seed.

True Potato Seed seedling production could be a challenging and profitable enterprise for an individual or individuals willing to attend to the details of containerized production and plant care. The Ministry of Agriculture has practiced this technology for several years at their potato research station and offers to counsel, train and encourage persons who are willing to provide this valuable service to the potato growers of Sri Lanka.

Appendix Notation 2

PROPAGATION OF SEED STOCK FROM TIP CULTURE

Micro-propagation is a special practice in which small pieces of plant tissue are regenerated in an artificial soup-like jelly called the culture medium under disease free conditions. The tips of leaves, tips of roots seed embryos, anthers, male flower parts, and even single cells can regenerate entire plants, in a moderately short time and in small space.

One mature plant can provide enough tip material for thousands of regenerated plants, and from this procedure of multiplication this part of micro-propagation is referred to as *Tip Culture*.

In most vegetatively propagated vegetables including garlic, potato, sweet potato and asparagus, tip culture provides a means of producing new planting material which is free of virus diseases. These virus free plantlets, capable of growing into mature crop plants can be used by farmers to produce superior crops or by scientists to detect virus diseases.

In some countries almost entire crop plantings are from virus free often designated VF, plantlets. Many flower, fruit and ornamental landscape plants have used tip culture extensively. In vegetable crops, garlic, irish potato and sweet potato are frequently made virus free by this method.

The advantages of micropropagation are many. In woody ornamental, tip cultured plants are usually more compact, more uniform and have a better top to root ratio. Sometimes the removal of even low levels of virus presence can make major changes in a crop. In sweet potatoes VF plantlets have nearly all storage roots of the same size instead of several jumbo, several large and many medium and small size storage roots ! Many early Irish potato varieties lose their earliness when VF plantlets are used. Many of the multicolored ornamental shrubs turn out solid green leaves instead of the interesting yellow, red and purple variegated leaves we ordinarily enjoy.

The disadvantages of micropropagation include the need for laboratory space and equipment; the need for specialized training; and the need for space to shelter the young plantlets during the period after they are produced in the laboratory until they are large enough to go to the crop field. These needs can cost very much for *fancy*, to rather little for simple operations. The one thing that can not be minimized is the need to have a well trained technical person to supervise the production sequence. It is estimated that labour costs represent 80-85% of the cost of a micropropagation operation. Included in this technology, the following are required:

A. Media Preparation Room:

Media supplies are compounded, sterilized, stored, ready to receive the tissue to be propagated.

B. Transfer Room:

A sterile facility with air and temperature controlled cabinets in which the tissue is placed on the sterile media.

C. Culture Room:

Where the young tissue grows into more mature plantlets.

D. Cold Storage facility:

Wash room and storages used to back stop the aseptic operation.

E. Acclimatization Facility:

Houses the young plantlets after transfer from the sterile test tube or flask into a soilless media pot or tray to allow development into a field ready transplant.

The stages of micro propagation can generally be classified into the following stages:

Step 1: Cleaning and surface disinfection of tissue to be excised or removed, household bleach is often used.

Step 2: Placement into sterile culture medium so that multiple *shoots* can develop, multiplication.

Step 3: Encouragement of *root* initiation and development at base of young shoot, in Vitro rooting.

Step 4: Transfer of rooted shoots into pots in a green house for acclimatization for field planting.

Most of the stimulation for the tissue to form shoots and roots is controlled by the manipulation of growth regulating chemicals in the cultural medium or broth. An example of a very simple cultural medium and prop for the micro propagation of apical and axillary buds from sprouted Irish potatoes includes the following materials, condition and operation (from: Kyte, Lydiane, 1992 plants from test tubes, timber press, Portland and Oregon)

POTATO, Solanum tuberosum. Solanaceae.

Explant : Apical and axillary buds from sprouted tubers.

Treatment : Dip shoots in 70% alcohol. Stir 10 minutes in 1/10 bleach plus 9.1% Tween 20. Rinse 3 times in sterile distilled water.

Medium : ms with inositol, thiamine, kinetin, and GA_3.

Light : 16 hrs light/ 8 hrs dark with 300 f.c. from cool white florescent light.

Temperature: 23^{0}C.

Discussion : Because potatoes are very subject to disease, tissue culture is an ideal way to multiply disease-free stock. The method of micropropagation is nodal propagation. Establishment of the primary explant requires approximately 8 weeks. Nodal multiplication rates vary from variety to variety and from line to line a line is all those plants derived from a single tuber. On this particular medium, roots develop along with shoots. A separate rooting medium is not needed. Transfer to soil is readily accomplished in a mist bench or a humidity tent.

Reference : #52, #107, #113, #155

TABLE 2

Potato Medium

Compound	**Stage I, II AND III mg/Liter**
Ms Salts	4628
Inositol	100
Thiamine HCI	0.4
GA_3	0.1
Kinein	0.5
Sucrose	30000
Agar	7000
pH	5.7

Persons considering micropropagation as an enterprise *should prepare themselves thoroughly* by reading and training. The ministry would help train technical personnel and advise on establishment of an appropriate facility.

The seedling production section of this report serves a vital link in successful micropropagation during the acclimatization stage.

Micropropagation could be a very profitable and valuable contribution to Sri Lanka potato, garlic and sweet potato production.

Appendix Notation 3

BACTERIAL WILT MANAGEMENT: SUGGESTIONS FOR TOMATO

A. Organism Characteristics

1. Casual Agent : ***Pseudomonas Solanacearum,*** E.F. Smith

2. Common Names : Southern Bacterial Wilt
Granville Wilt
Brown Rot
Brown Blight

3. Pathogen : Specialized biotrophic pathogen of plant vascular tissue, does not form spores.

4. Occurrence : Widespread in tropical and sub-tropical areas. Seldom found in temperature zone production.

5. Host Range : Solanaceous plant, Agronomic and weed reci species, exists as 3-5 strains and 5 or more pathovars almost all nightshade weeds are potential hosts.

6. Symptoms : Affected plants wilt rapidly, without spotting or yellowing of leaves. Vascular tissue dark and watersoaked, streams when stem cut, Grayish yellow slime evident.

7. Conditions favouring development and infection:

   High temperatures: 21°C to 32°C High soil moisture: Wet weather, Poor drainage Infection enhanced by very moist soil, waterlow waterlog Wilt expression increases as soil moisture drop

8. Persistence : Requires solanaceous hosts to sustain, can not tolerate dry fallow periods for more than 6-9 months, or without host crop or weed.

9. Sources of Infection : Primary source of infection is contaminated soil, must have free water film present

10. Methods of Spread : All require soil moisture

    a. Contaminated farming equipment (Mechanical transfer).

    b. Drainage water or surface water movement due to rain or irrigation.

c. Contaminated seedlings.

d. Cultural practices creating root wounding especially during water logging periods.

B. Management Opportunities

1. Rotation : Grass family crops not susceptible should be considered in rotation for one or more crop cycles to reduce inoculum.

2. Sanitation :
   a. Use only disease free seedlings.
   b. Use only *clean* cultivation machinery and tools when moving from field to field, growing tomato family crops.
   c. Maintain as weed free culture as possible.

3. Eradication Efforts :
   a. Prevent over wintering of bacterium in crop residue of infected plants.
   b. *Soil fumigation* is appropriate only in high return production situations.
   c. *Soil Solarization* is appropriate in developing countries, allows 1- 2 months lowered disease potential.

4. Disease Minimization Efforts
   a. Improvement of soil drainage of crop field.
   b. Use of raised beds may help to enhance root aeration and reduce excess soil moisture conditions.
   c. Rotation, weed free following and strict control of disease free seedlings.
   d. Reports of reduced inoculum at high pH soil conditions may be worthy of testing further.

5. Use of Resistant Varieties:

   Background

   a. Bacterial wilt of solanaceous crops is pan tropic and sub tropic, considered major production constraint.
   b. Resistance is multigenic, recessive and illusive.

c. It is believed that three or more strains exist, and that five or more pathovars have been isolated.

d. Very few cultivars have been listed as resistant across ecozones.

e. A short list of tolerant cultivars may be worthy of testing in Sri Lankan production area.

- Capitan and cariabe, possible Latin source
- Rodade popular in Southern Africa
- Durable Shinkuro, Japanese Sources
- Also listed are Saturn and Venus, Source N.A.

Appendix Notation 4

METHODS FOR PRODUCING HIGH QUALITY VEGETABLE SEEDLINGS WITH CONTAINERIZED TECHNOLOGY

Authors : Phillip Mowbray, Gamini Kumarage and George Marlowe.

This publication has been prepared as a separate presentation for ready distribution. The 30 page booklet covers the following topics and is available from AgEnt Headquarters, Deutsche Bank Bldg., 5th Floor, Colombo 3.

Table of Contents

Appendix Notation 5

REDUCING BACTERIAL, FUNGAL, NEMATODE AND WEED LEVELS IN SOIL OR SOILLESS MEDIA BY VARIOUS TREATMENTS.

There are wide range of practices and materials which can be used to help reduce the level of troublesome organisms from the seedling production operation. Sri Lankan growers should consider non-chemical measure first rather than chemicals first, because:

- Non-chemical methods are usually cheaper
- Non-chemical methods are usually less dangerous
- Non-chemical methods can usually require less equipment
- Non-chemical methods can usually be done with materials already on the farm
- Non-chemical methods are usually less damaging to the environment due to leaching of chemicals into the underground water, etc.

The *ideal* soil clean-up procedure would be to kill harmful organisms but allow beneficial organisms to survive.

Some of the most important non-chemical clean-up procedures involve heating of the soil or media. A brief review of how temperature can be used to reduce soil or media problems requires an understanding of *Thermal Death Points* of various organisms as follows:

Thermal Death Points of some of the most important problem organisms in seedling production (from: UNIV California Propagation Manual 23).

Table 3

Organisms Killed, Soil Moist (Various Time)	Temperature ° C	Required ° C
Resistant Weed Seeds Resistant Plant Viruses	93.0 - 100.0	200 - 212
Most Weed Seeds All plant pathogenic bacteria Most plant viruses	71.1 - 82.2	160-180
All soil insects Most plant pathogenic fungi Most plant pathogenic bacterial All worms, slugs All centipedes	60.0 - 72.1	140-160
Botrytis Gray mold	54.4 - 60.0	130-140
Rhizoctonm Solani Sclerotium Rolfsii Sclerotinia Sclerotiorum All Nematodes	48.9 - 54.4	120-130
Water molds	43.3 - 48.9	110-120

There are many ways to heat soil. Electric heating is one of the most expensive, but even a kitchen micro-wave can be used to sterilize small batches. Some growers can afford soil ovens, auto-claves and pressure cookers but most must use cheaper methods.

An old dump truck body, the tray or part that holds stone, sand or soil can be used for many years as low cost cooker or steamer. The bodies can be taken from wrecked trucks or purchased new. The body needs to be placed on concrete blocks or stones to elevate it at least 55 or 60 cms off the ground.

For dry heating, moist soil is placed into the truck body and covered with sheet metal. The depth of the moist soil should not exceed 1 meter. An uncooked potato should be placed 7-8 cms from the top of the pile before covering. A fire built under the truck body should be maintained for 3 to 3 ½ hours. If the potato is *cooked* the soil mass may be considered sterilized.

For steam heating, a mesh grill of some type should elevate the soil mass from the bottom of the truck bed at east 10-15 cms. Water is placed into the area between base and grill before soil and uncooked potato, are loaded onto the truck bed. The steaming method only requires 2- 2½ hours of under-fire, thus uses less fuel. Also a layer of Jute sacks or old rug like clothes can be used to hold in the steamed heat instead of a metal cover.

For growers in areas where hot sun an minimum cloudiness can be expected for three to four weeks *sun-cooking* can be used. If a concrete floor out of shaded areas is available, the soil or media to be cooked should be placed on the floor in a flat layer no deeper than 25 - 30 cms. If a concrete floor is not available a black plastic sheet will do, as long as the soil is protected from non-treated soil beneath.

After the soil or media is placed onto the floor or plastic sheet should be well moistened with a hose or sprinkling can. A clear or slightly milky plastic tarp should then be placed over the 25 - 30 cm deep mass and the edges should pressed down with stones or bricks to help retain the moist hot heat generated during the daylight sunny hour.

The sun cooking method is also called solar pasteurization. A minimum of 14 days, of hot sunny days, should be allowed before removing the cover and using the soil or media. A 21 day period may be needed if the sun hides for extended periods.

Clean-up methods using chemicals require special care, materials and equipment. Growers using chemical methods should follow directions on the label of the container carefully. Failure to follow directions can be dangerous as well as in effective. These materials are either liquids or gases.

Materials commonly used are Methyl Bromide; Chloropicrin (tear gas). Vapam, Sodium N-Methyl Dithiocarbamate Dihydrate.

Soil drenches can be applied if specific diseases, mostly for fungal pathogens are identified as problems as follows:

1. Rhizoctonia, Sclerotinia and Sclerotium: Quintozene also known by trade names PCNB, Terraclor.

2. Rhizoctonia, Cylindrocladium, Fusarium and Verticillum: Benomyl, Benlate, Tersan 1991.

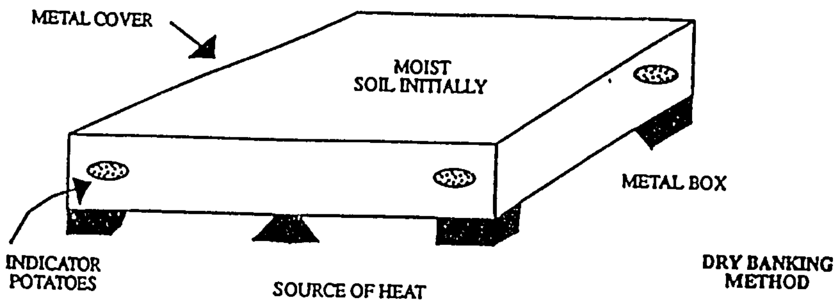
3. Phythium and Fusarium: Captan, Orthocide.

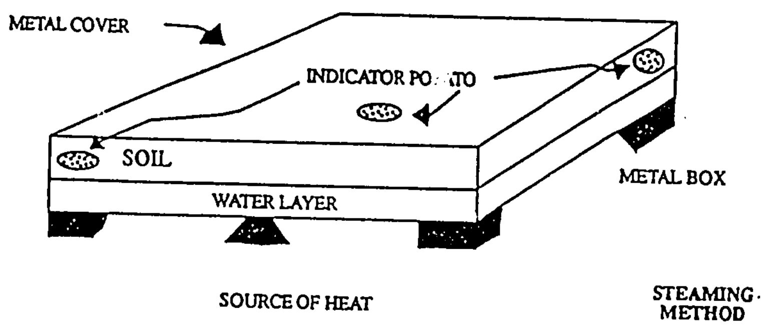
4. Phythium and Phytopthora: Etridiazole, Terrazole, Truban.

These drenches are rather specific in their action and should only be used with proper identification of the fungal organism one wishes to control.

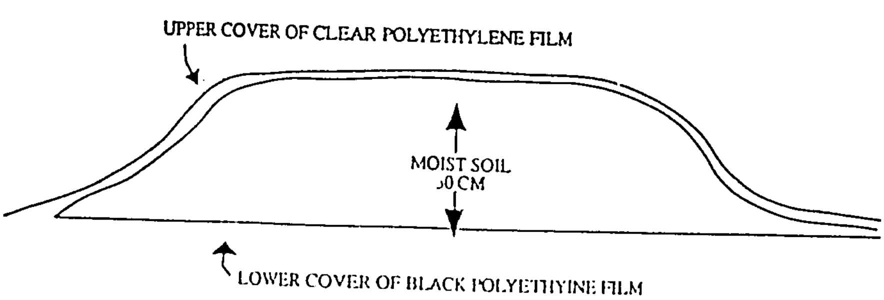
For most plant growers the non-chemical methods are satisfactory and cheaper. The ideal would be to use disease and pest fee materials such as sand, peat coir dust well rotted sandust to make the media. This would avoid clean-up procedures inmost cases.

PRACTICAL SOIL CLEANSING METHODS





SUN OR SOLAR PASTEURIZATION METHOD



Appendix Notation 6

METHODS FOR IMPROVEMENT OF TOMATO MARKET FLOW

Currently most Sri Lankan tomato production is done after or before a rice crop, and acts more or less as a sandwiched in operation creating massive short production-short harvest glut. This could be modified at low cost, using a scheduling technique developed in the USA for tomatoes for processing.

Let's use an example for illustrive purposes. A tomato farmer would have to have control over his seedling source, or purchase plants from a responsible transplant grower.

1. In that planting to the field must follow soon after the Yala rice crop there is little opportunity for staggered plantings in the field as is done with cannery tomatoes to match the daily raw product needs of processing plant.

2. If an acceptable field transplanting date is 1 May for example, the *first* seed sowing date in the transplant production shelter would be approximately March 1. As soon as the tiny tomato seedlings show their first true leaf to be 2 centimeters long the system begins is *clocking*.

3. When planting number 1 shows 70-80% of its seedlings to have true leaf size of 2 cms, the second planting is made.

4. Planing 3 is made when planting #2 has reached 2 cm True Leaf Stage (TLS).

5. Planting 4 is made when planting 3 shows 2 cm TLS.

This system involves two rather well established physiological constants. One, is that the time from 2 cm TLS to harvest is rather constant for each variety of tomato. Secondly, is that the seedling integrates its total environment independently of the calendar and responds mostly to hours of sunlight and temperature degrees that are accumulated, in its development rate.

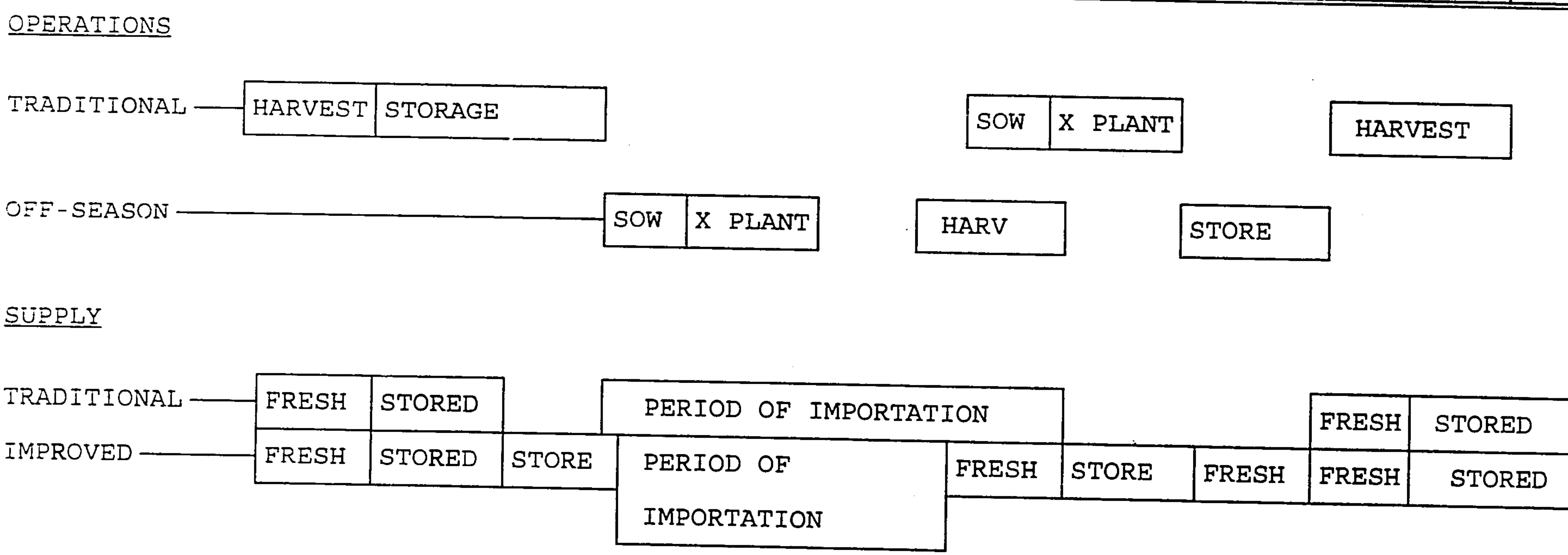
By having different maturities of transplants ready for the 1 May field setting date all can be set into the field at the same time but will mature at four different peaks instead of one peak which creates the market glut in current tomato growing.

The method is simple, low cost and effective, but it does depend on a reliable transplant producer with a protected structure. It allows the scheduling before field setting, avoids the rice-squeeze and should provide growers, traders and consumer with a better quality and more uniform marketing season.

Appendix 7

PROPOSED PLANTING AND HARVEST POSSIBILITIES FOR SRI LANKAN BULB ONIONS

Event or Climate Condition	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVE
Rainfall mm	33	34	90	260	268	245	91	51	75	193	87	16	32	34	90	120mm
Temp^{0}C	32	33	33	32	30	29	29	31	34	34	32	32	32	33	33	32^{0}C
Days, Hrs	12.5	12.3	12.2	12	11.8	11.7	11.9	12	12.2	12.4	12.5	12.5	12.3	12.2	12	12



Appendix Notation 8

SUGGESTIONS FOR IMPROVED ONION STANDS

The onion stands in Sri Lanka are among the most variable in the world for several very unfortunate reasons. In one field at harvest our group observed almost unbelievable variability in which red skin, brown skin, and white skin bulbs were co-mingled; some bulbs had not bulbed yet, most had formed bulbs and some had already sent up flower stalks, some even had hard seed in the flowering umbel.

The mixing of varieties, maturities and seed ages would not be tolerated in most countries of the world. Legitimate seedsmen are bound by strict seed laws to have seed true to name, lot purity and seed age carefully separated.

The onion growers of Sri Lanka deserve to have seed that will behave according to proper photoperiod, will be true in color, shape and size range, pungency and flavor and will mature within a rather predictable number of days from sowing. It is almost impossible to store onions effectively if many are immature, split or bolted.

Onions have a very short seed longevity. After one year geminability drops and bizarre behavior during crop growth can be expected.

Location of reliable and ethical seed source for Sri Lanka onion production should be a top priority effort of AgEnt, USAID, the Ministry of Agriculture, Farmers Associations, etc.

When true to name, true to age seed is located, farmers will be able to plant, grow, harvest and market or store a more uniform, more reliable, more profitable crop.

At present, onion supply in Sri Lanka is import dominated or 9 to 10 months of the year. By using containerized seedlings started under protection during the proper photoperiod (Nov - Feb). A field of disease free, vigorous plug plants could be set in the field in January as the rains subside. With good seed, matured bulbs could be harvested in mid-March, stored until the traditional crop is harvested.

As shown in Appendix Notation 7 this could easily reduce the import period, increase farm income and provide consumers with home grown fresher onions. Transplants from containerized seedling production provide higher survival than pulled seedlings, are more vigorous, and more uniform in growth and development.

Appendix Notation 9

SOME POINTERS FOR IMPROVED BULB ONION STORAGE

A. When to Harvest

- Bulbs should be lifted from the soil or after the leaves have fallen over turned yellow in color and started to dry out.
- Bulbs should only be harvested when soil is dry enough to fall off the bulbs easily and the harvest can be completed before a rainy period.
- Care must be taken to avoid damaging the bulbs as they are removed from the soil, transported into the sorting area and placed on the floor or table for sorting.
- Bulbs may be allowed to field dry for few hours in windrows if there is no danger of rain.
- Bulbs can be protected from compress bruises better if harvested in smooth wood crates or plastic pails rather than in Jute bags.

B. Importance of Sorting Before Storing

- Careful handling reduces non-visible damage. An onion which has been dropped cut or bruised may not show obvious damage but will be pre-disposed to invasion by bacterial and fungal disease organisms where surface tissue has been weakened.
- Bulb should have dry, tight, thin necks; the outer leaf scales should have dry scales, with no soft inner leaf exposed.
- Bulbs with thick necks (immature), cuts, rots or insect damage should not be placed in storage as they will lek moisture and promote soft rot at the wet spots wherever they touch other bulbs.
- Only clean, whole, intact, dry mature onion bulbs should be placed in storage. Imperfect bulbs should be sold or used immediately but not used for long term holding.

C. Care During Storage

- Shelf storage usually allows for better ventilation than bag storage; good ventilation and air movement through the layer of bulbs is one of the most important factors in onion storage.
- Bulbs should not be piled deeper than 10 - 12 cms deep to insure proper drying and ventilation.

- Bulbs in storage should be examined once a week so that early detection and removal of rotting or sprouting onions can be removed before they influence healthy bulbs near by.

- Bulbs should be *turned* gently at least every week to 10 days to reduce wet spots between bulbs.

- Bulbs should be shielded from rain rodents and other wild life.