MAHAWELI ENTERPRISE DEVELOPMENT

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NURSERY DEVELOPMENT OF PAPAYA AND MANGO,
PAPAYA GROWERS' GUIDE
AND
TECHNICAL NOTES FOR BUSINESS PLAN FOR MIXED FRUIT CULTIVATION INVESTMENT

A short-term consultancy report by
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INTERNATIONAL SCIENCE AND TECHNOLOGY INSTITUTE, INC.
WITH:
ERNST & YOUNG CONSULTANTS (Sri Lanka)
DEVELOPMENT ALTERNATIVES, INC.
HIGH VALUE HORTICULTURE, PLC.
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CONSULTANTS TO THE MAHAWELI AUTHORITY OF SRI LANKA
The Mahaweli Enterprise Development Project

The Government of Sri Lanka and the international donor community have given high priority to the development of the natural and human resources of the Mahaweli river basin. The first phase of this development, the construction of dams, irrigation and power systems, roads and other physical infrastructure, is largely complete. The second phase, settling the land and forming an agricultural production base, is well under way. The third phase, the major challenge for the 1990's, is the building of a diverse and dynamic economy, improving employment and income prospects for Mahaweli settlers and their families. In this phase the private sector has a leading role to play.

The Mahaweli Enterprise Development Project (MED) is a USAID-supported initiative of the Mahaweli Authority of Sri Lanka to promote investment and business development in agribusiness, manufacturing, tourism, minerals and services. MED directly assists small, medium and large-scale investors with technical assistance, marketing support, training, business advisory services and credit. MED also provides policy assistance to improve access to resources, such as land, water and capital, and the legal and institutional framework for enterprise development.

The official MED implementing agency is the Employment, Investment and Enterprise Development Division of the Mahaweli Authority. The main MED technical consultancy is provided by a consortium led by the International Science and Technology Institute, Inc., a private consulting firm with head offices in Washington DC. Other firms in the consortium are Agroskills, Development Alternatives, Ernst and Young, High Value Horticulture and Sparks Commodities. Marketing services are provided by SRD Research and Development Group, Inc.
Mr Ben Hatfield, a consultant agronomist, assisted in July 1991, in the feasibility study of an integrated fruit production and processing operation in the Mahaweli. He prepared this guide and presented it to a workshop during the course of his assignment.
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NURSERY DEVELOPMENT OF PAPAYA AND MANGO

1. GROWING MEDIUM

A suitable growing medium can be achieved with the following mix, although there are many variations. Mix 2 parts of soil, 1 part of coarse sand, 1 part of aged manure and 1 part of aged saw dust. This will give good aeration, water holding capacity and some nutrition. Add to this 10 lbs of Triple Super Phosphate being sure to mix in thoroughly. Other fertilizer can be applied once plants are growing.

The mix should be sterilised with either Vapaam or Methyl Bromide and subsequently handled only with sterilised tools (washed in a Chlorine solution). When using Vapaam the mixture should be turned over every 3 days. Methyl Bromide is preferable and disperses more rapidly. Being a gas it is necessary to seal the mixture to be fumigated with plastic.

The nursery area should be fenced off properly and all vegetation growing in the area removed or killed with sprays. A slightly sloping area assists drainage in wet periods. A good clean water supply is essential.

2. SANITATION

All tools, trays, watering cans, table tops, mixing or filling surfaces, plastic or styrofoam trays and workers hands must be cleaned with a strong chlorine solution, about 2,000 p.p.m., every time they are to be used. Casual visitors must be kept away from the mix and asked not to touch the growing plants and equipment.

The packaged nursery mixes claim to be sterile but they should be drenched with a Ridomil or Benlate solution prior to planting. These nursery mixes are most likely to be used for papaya seedlings, when the drench can be applied in the tray before planting. Regardless of crop, the seed should be treated with Benlate prior to planting.

3. WATER SYSTEMS

Sprinklers in a nursery should be of the low pressure (8 - 10 p.s.i.) fine mist type, that will water all the plants at one time. There are wetting patterns from 90° - 180°. These are suitable where a mains water supply is available. Watering from a hose is feasible, but care is needed not to gouge out the soil around plants.
For the watering of trees in bags the best system is a polytube running the length of a double row, with spaghetti tubing branches. Insert spaghetti tubing through a hole punched near the top of the bag. The water can then be run as necessary. Emitters on the end of spaghetti tubing would also serve well. This system will work at very low pressure.

A watering can is very slow, but useful for applying soluble fertilizer mixes.

Some parts of the nursery will require a shade cover which blocks 50% of sunlight. Under part of this a mist house can be constructed by putting up plastic sheeting to form a room, usually about 8 feet square, to keep in the humidity and give protection from the wind. Two rows of the low pressure sprinklers, or stationary misters, set about 4 feet above the ground, will give good water coverage. This room is useful for propagating cuttings and bare root plantings.

4. **PAPAYAS**

See the growers guide for seed preparation and germination. Bottom heat may be needed to hasten the germination of seeds between the towels; a commercial heating pad, set at 90°F (35°C), under the towels will reduce germinating time. Moulds will develop when seeds take longer than 4 or 5 days to germinate, in which case seeds should be washed with a mild fungicide solution and put in full sunlight for 10 minutes.

When seeds begin to crack pick over them daily to prevent the roots becoming too long. The cracked seeds can be soaked in a mild Ridomil solution (1 tsp Ridomil to 2 gallons water) before planting in the trays. Use the same solution to drench the planting mix in the trays. The trays should be kept under 50% shade until the first two leaves appear, when they should be moved into full sunlight. Remember that too much shade will stretch the plants. Spray the seedlings every 5 days (3 in wet weather) with a mixture of Ridomil and a Copper proprietary formulation such as Cuprox. Apply a foliar fertilizer containing minor elements with a watering can once every four days. If foliage is very lush reduce to 1 application a week. Plants will be ready to plant out, at 4 inches, in about five weeks from germinating.

5. **MANGOES**

Seed should be selected from fully ripe fruit selected from vigorous, healthy trees. This is to try to produce the most vigorous seedlings. There is considerable variation in mango seeds collected at random and their genetic differences can show up in the performance of the seedlings.
After the seed has been cleaned, the husk is carefully removed and the seed dipped into a solution of 1 tbs Benlate and 1 tbs Captan, in 1 gallon of water, for 15 minutes before planting in the sterile media. The mango seed is kidney shaped. Plant the seed with the indented side down, (i.e. the convex side up), no more than 2 inches deep. 1 inch will suffice. Germination should occur within 2 to 3 weeks under good conditions. Cover the seeds with a light layer of grass (or substitute) until germination.

When the shoots are 3 to 4 inches high the seedlings can be transplanted into the nursery bags that have the mix containing TSP. If no TSP is present in the mix place 2 tbs at a depth of 4 inches in the bag. At transplanting clip any tap roots that are not growing straight down and dip in a Benlate solution.

The plants are moved to full sun 2 to 3 weeks after germination and pruned to leave one dominant shoot. Keep adequately watered and apply some complete foliar fertilizer each month. This will ensure a good rate of growth. Two points to remember are: the polythene bags should have adequate aeration holes punched in the lower half, and mango seed loses its viability very quickly after cleaning, but can be kept between charcoal layers for about a month.

For large scale plantings, seeds can be planted 1 foot apart, in specially prepared nursery beds and transferred to cans or polythene bags at 6 or 7 inches, or later. The tap root may need trimming but growth is faster in the nursery bed than in the bag.

In tropical Sri Lanka it is possible that suitable grafting material, when the buds begin to swell on the terminal shoot, will be available year round. After harvest, but prior to the next growth flush could be the best time to collect suitable grafting wood. If the terminals are too big for the rootstock, the terminal portion of the shoot can be cut back and a new shoot forced out and allowed to harden. After the wood on the new shoots is no longer sappy the leaves should be removed. When the buds begin to swell clip the shoots to 3 or 4 inches and side veneer graft on to rootstock of the same diameter.

A small plastic bag should be placed over the grafted scion and tied below the graft to create a moist atmosphere that will keep from desiccating. When the first leaves appear remove the bags but keep the plant in shade until these leaves harden off. Then place in full sunlight.
EARLY MANAGEMENT OF THE ORCHARD

- Ensure that drainage is sufficient.
- Plant on raised mounds or along a raised bed.
- Water well after planting to settle the soil and eliminate air spaces.
- Protect the soil from the sun.
  * Mulch with straw or other suitable material round the plant AND
  * Plant vegetables in the rows in wet areas or plant a leguminous cover crop which is slashed down periodically. (Glyracidia)
  * Also in wetter area slash the weed growth frequently but clean around the plant.
- In very hot weather a protective paint can be used; whitewash or a white water emulsion paint.
- Plant or erect windbreaks. Wind can slow growth due to the fact that the plant uses energy to resist it.
- Watch for pests. Plants are very vulnerable when small.
- Keep good records of water and fertilizer applications. Make this a habit.
1. **SITE SELECTION**

Good drainage is absolutely essential. Papaya thrives in a slightly acid range of 6.5, but good crops can be obtained anywhere in the 5.5 to 7.5 range, with the correct fertilizer amendments according to the pH value.

Papayas can be damaged if water stands for more than 12 hours. Site should be sloping with no low spots where water can accumulate. Tree rows should be aligned with the slope if erosion can be avoided. Avoid heavy clay soils; a silty clay loam or a sandy clay loam are preferred. Air movement in the soil is critical for good growth, hence soils that contain gravel or rock are acceptable.

**WATER**

Before planting papayas the irrigation system should be tested to make sure it is adequate. No water, no papayas.

**OTHER CROPS**

Do not plant other crops in the papaya rows or next to the papaya field. Cucumbers and melons can harbor virus diseases; corn can harbour insects which spread disease, especially leafhoppers.

2. **LAND PREPARATION**

Plough the land at least two months before planting, burying as much crop debris as possible. Avoid burning in order to maintain the organic matter. If the organic content of the soil is low a green manure crop, such as Crotalaria Caricea, should be planted and ploughed at the 1/2 bloom stage.

**RIP SOIL**

Soil, to a depth of 3 feet if possible, where the beds are to be made. Two or more passes may be necessary to achieve this depth. If possible, rip across the bed line too.

**BEDS**

Hill beds up to 10 - 18 inches over the ripped soil, levelling the top which will leave a flat area 2 feet wide. The sides should have a gentle slope to avoid erosion. Again two or more passes may be necessary to achieve the required help. Bedding is important for drainage.
MANURE

If manure is available spread over the top of the beds. Use aged material. Plastic mulch can be used. This is essential if the beds are to be fumigated with Methyl Bromide. Place the plastic over the top of the beds, after laying the irrigation tubing.

3. IRRIGATION

Drip irrigation is essential for papaya production. Furrow and sprinkler systems are definitely unsuitable, spreading disease and impeding drainage. Most of the feeder roots are in the top 6 inches of soil, and this area should be kept damp, but not too wet. For most loamy soils two irrigations a week, in dry weather, should be sufficient. Very sandy, coarse soils may need to be irrigated three times a week.

Sufficient water should be applied to wet the soil profile. Avoid a heavy build up of water in clay subsoils as this may damage the roots. Remember that a bearing papaya tree in full production can use 10 gallons of water a day.

Sub-mains from the main line to the row ends, consists of 1½ - 2 inches Polyethylene tubing (usually lay flat). The lateral, along the top of the bed, can be ½" poly tube with emitters or spaghetti tubing at each planting site, giving 1 to 2 gallons of water per hour. Bi-wall with holes (outlets) spaced at 8 or 12 inches, can be used satisfactorily, but will water the whole bed which is unnecessary for the first 2 months.

The choice probably depends on material cost and availability. After 2 to 3 months the poly tube can be pulled along the bed until the emitter is under the edge of the leaf canopy and another emitter added on the opposite side. Two emitters will be required per tree by this stage. Good filters are essential to prevent the holes clogging. A 120 mesh screen is needed for emitters and a 200 mesh for bi-wall tubing.

In any irrigation system the first step is to test the pump and water source to ascertain exactly how may gallons can be delivered to the field. Do this before materials are purchased. Drip irrigation systems require constant attention. Filters should be cleared, or flushed out, before each irrigation. The drip lines should also be flushed as frequently as possible. In certain conditions additives can be added to the water a few moments before closing down, either to help clean out the tubes or chlorine to kill bacteria.
4. **VARIETIES**

The Hawaiian Solo varieties, while prolific bearers, may not be the best ones for drying. Larger fruit probably have a better meat to skin and cavity ratio. Sunrise Solo is the most adaptable of the solo types, producing fruit up to $\frac{1}{2}$ kg in weight. One tree can produce in excess of 50 kg of fruit under very good conditions.

- A selection of local varieties is the prudent way to start.

- The literature mentions many varieties from India, Indonesia, Queensland, West Indies and other places. A comparison of three local selections in Surinam with three Hawaii cultivars showed that the local selections out-yielded the Hawaii cultivars. The best yield was 59.8 kgs per tree. At a plant population of 500/ha the yield would be 89 tonnes/ha after the first year.

- A high yielding hybrid (seed will not grow true to type) call Cariflora has been developed in Florida. It is very precocious, bearing 1 round fruit of 1-2 kgs low down on the trunk and should be tried in Sri Lanka.

Remember that papaya are cross as well as self pollinated, the pollen can be carried a fair distance. This means that no variety will maintain its purity unless planted in isolation. A few trees should be selected for seed and a number of flowers bagged until pollination is over and the fruit is developing. These fruit should then be carefully marked.

5. **SEEDLINGS**

Seeds can either be planted out directly in the field or raised in a nursery and planted out at 4 inches high. Single trees raised in polythene bags can be kept in the nursery longer, but it is very important not to overcrowd plants, or shade them, as spindly plants will result. In the field these plants will bear fruit higher up the trunk, bear less fruit and be more susceptible to wind damage.

**GERMINATING SEEDS AND NURSERY**

Dry seeds can be soaked in warm water (blood heat) for 24 hours. The water should be changed or stirred periodically to re-charge with Oxygen. Thirty minutes prior to removing the seed add a tsp of Captan or Benlate to the water. The seed is then placed between clean cloth towels and kept moist until seed begins to crack. A temperature of 95°F (35°C) is optimum for germination and little will occur below 75°F.
As the seeds begin to crack plant them directly in the field or in styrofoam plastic trays. Fresh seed, directly out of a selected papaya, has to have the gelatinous coating removed. This is best done by soaking in acid for a day. 1 part of concentrated battery acid is added to 3 parts of water to make the desired solution. After soaking, the wet seed is then rubbed on a screen to remover the coating, leaving a bare seed looking like a small raisin. The seed can now be placed between the towels to germinate.

Planting directly in the field is risky as the germinating plants are vulnerable to insect damage, especially grass-hoppers, resulting in many misses. A light grass mulch prevents rapid drying. Seedlings can best be raised in styrofoam trays. These are divided into 1 inch squares (approx.), about 2 - 2 1/2 inches deep. The sides taper down to leave a small open square at the bottom. This allows free drainage and prunes roots. A sterile medium is used in the trays, either a purchased nursery mix or are made up of soil, sand aged saw dust or perlite which has been sterilised. Different combinations are used. Plant ½" deep. Put the seeded trays on racks about 3 feet off the ground, under 50% shade, until the plants are about 1 inch tall or after the emergence of the first two leaves. Then place in full sun. If no shading material is available keep the afternoon sun off the trays. Spray the trays every five days with a copper and Ridomil mixture, following the correct mixing instructions. Water twice a day in very hot weather, otherwise once will usually suffice, depending on the holding capacity of the medium.

Add 1 tsp of water soluble fertilizer containing micro-nutrients to 1 gallon of water every three days.

6. **SPACING**

The following are commonly used spacing, although the tendency has been towards heavier plant populations.

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Trees could be planted in blocks with 15 foot roadways if desired. Nine feet between rows is satisfactory if a small tractor and equipment are used. Ten feet is more comfortable. Six feet within the row leads to overcrowding. 11 feet between rows allows picking machinery to pass.
PLANTING

Solo papayas will turn out to be 1/3 female and 2/3 hermaphroditic. Therefore three plants are usually planted per planting site, six inches apart.

Statistically, only one in 27 planting sites will turn out to have three female plants. The sex is not known until the first buds appear. The female plants are removed as soon as possible; the best hermaphroditic tree is left if a choice still exists.

Half pound of Triple Super Phosphate (TSP) is buried in the ground at each planting site. For field planted seed make three holes 6 inches apart and 4 inches deep. Put ½ lb of TSP in each hole, without mixing, placing two cracked seeds in the soil above, ½ inch deep. Before planting nursery seedling place 1½ lbs TSP 4 to 6 inches deep at the planting site. Do not mix into the soil. If the seedlings are carefully planted out, the soil properly firmed and the soil level with the bottom of the trunk, the growth will barely be checked. Irrigate adequately as soon as possible and do not allow the soil to become too dry, at least for one week.

FERTILIZER

The following is a guide. Soil sample and tissue analysis of growing crops could lead to modifications to suit local conditions.

At planting - 1½ lb TSP under planting holes. 1 oz Urea (or substitute) and 1 oz of Potassium Chloride or Potassium Sulphate in a band between the water source and the plants. Other fertilizers can be used too, according to soil conditions e.g. Iron and Magnesium Sulphate on high pH soils.

Month 2 and 3 2 oz Urea and 2 oz Potassium fertilizer, per tree, banded between the tree and water source. Other fertilizers as necessary. (Determined by soil analysis).

Month 4 4 oz Urea and 4 oz Potassium fertilizer each tree.

Month 5 8 oz Urea and 8 oz Potassium fertilizer per tree. ½ lb TSP buried in ground near water source underneath the outer leaf canopy; split ½ lb each side.
Month 6  
and up  
80 lbs Urea (or substitute) and 100 lbs  
Potassium fertilizer per acre, either through  
drip system or broadcast over the entire  
area.

As growth continues the amounts could be modified, according to  
tissue analysis results and appearances.

FOLIAR SPRAYS

If micro-nutrients problems are anticipated, foliar sprays  
containing micro-nutrients can be added to the regular fungicide  
sprays. Epsom salts (Magnesium Sulphate) can also be added at  
rate of 10 lbs to 100 gallons of spray mix.

9. WEED CONTROL

a) Gramoxone (Paraquat) at 2 tbs (1 oz) per gallon for  
small grasses and broad leaved weeds. Spray only in  
air still conditions. Do not allow spray to drift on  
to young plants. Damage to young green trunks can lead  
to rot and eventual collapse of a tree later, when  
heavy with fruit. When the trunks are brown, at about  
one year, Gramoxone can be sprayed directly on to the  
tree trunk. Very young trees can be covered with  
buckets or drums while spraying.

Control should start before planting. Irrigate the  
beds before planting to germinate weeds. Spray soon  
after emergence. Plastic mulch would facilitate weed  
control.

Hand operated knapsack sprayers are ideal for this  
purpose. Pressure can be controlled by the operator  
and a variety of nozzles are available. Shields to  
prevent drifts are available. Use the lowest pressure  
possible to do the job. Coarse, large sized nozzles  
are best to prevent drift.

b) Roundup should be used to kill perennial grasses at 3  
tbs (1 1/2 oz) per gallon. Use spreader sticker and 2 tbs  
of Urea to enhance the kill. Again, do not spray on  
the trunks of the papaya, and avoid creating a mist.  
The addition of Nalcontrol II to Roundup will create  
larger drops, eliminating mist. After applying Roundup  
wait at least four days before spraying with Gramoxone.  
Dalton (much cheaper) can be substituted after 4  
months.
Diuron, a pre-emergent weed killer can be used between the beds and works well in conjunction with Gramoxone. Use at the lower end of the recommended dosage scale until the trees are over six months old.

Diuron can damage young trees in sandy soil. So on these soils spray a small test plot to make sure the trees will not be damaged.

10. **DISEASE CONTROL**

a) **MANZATE** (Mancozeb) should be applied, at 1.2 tbs per gallon of water (2.3 lbs per acre) every 2 weeks to leaves, flowers and fruit. This spray programme should start one month after planting and continue every 2 weeks for the life of the plant. For the first 2 months an ordinary hand operated knapsack sprayer will suffice, but from this point on a power operated sprayer will be necessary.

Back-pack motorized mist blowers are not satisfactory except on very small areas. Large volumes of spray solution should be applied, at high pressures (up to 300 lb PSI) to ensure complete coverage. A tractor operated high pressure air blast sprayer is ideal.

As the trees grow taller some modification to the machine will be necessary to raise the nozzles, and air blast outlet, so that the spray is directed on to the leaf canopy and fruit column on the upper trunk. Good coverage is important.

The diseases being controlled are leaf spot (Cercospora) on the leaves, Anthracuose on the fruit, and stem end rot. Anthracuose symptoms will often not appear until after the fruit has been harvested and packed.

Include an appropriate micro-nutrient foliage spray, at recommended rates, with each fungicide application.

b) **ROOT ROT** can cause havoc with papaya trees and can be caused by several types of fungi. Being so susceptible, good drainage is very important. By the time symptoms become apparent it is usually too late to effectively treat the cause.
Symptoms can be drooping of the older leaves or shortening and twisting of petioles on newer growth, premature yellowing and deterioration of older leaves and loss of vigour. The rot, at the ends of the small roots, can be easily seen when exposed. This may not be a problem in certain areas, in which case good drainage alone may suffice to ensure healthy trees.

Before planting local papayas should be examined. Any new varieties brought in to the country, such as the Hawaiian Solo types will almost certainly not be as tolerant to the local pathogens as the local papayas. Therefore, where considerable investments are concerned it is wiser to treat the soil in the following manner.

Fumigate the beds with Vapaam or Methyl Bromide prior to planting. Vapaam can be applied as a soil drench two to three weeks before planting. A plastic cover is not necessary. Methyl Bromide is a gas which comes in canisters. A plastic mulch over the bed, sealed with soil at edges, is necessary to contain the gas once it is released. Either of these two chemical will sterilise the soil, killing weed seeds as well as micro-organisms and nematodes.

 Phytophthora Palmivora can cause serious losses in papayas, can affect roots and the tops of trees, and is usually present in periods of heavy rain. Add Ridomil (Metalaxyl) to every second Manzate spray. Keep the orchard floor clean by removing all fallen fruit and culled or fallen trees. The initial symptom is drooping of the older petioles, rapidly spreading to the young growth and cessation of growth. White mould will appear on the fruit, spreading the disease. Infected trees should be removed.

FIELD SANITATION, REGULAR SPRAYING DIRECTED TO THE TARGET AREA, WEED CONTROL, USING CORRECT CHEMICALS AT THE CORRECT RATES ARE THE KEYS TO CONTROL.

Subsequently, every two months, apply 4 lbs of Terraclor, which is a wide spectrum soil fungicide, through the drip system at 4 lbs per acre. Rovral, another soil fungicide can be substituted for alternate applications.

As an alternative to fumigating with Vapaam or Methyl Bromide prior to planting, Terraclor can be applied through the drip irrigation a few days prior to planting.
c) VIRUS DISEASES These are prevalent in Sri Lanka. The best precaution is to keep the orchard floor clean of weeds, have a good insect control programme and avoid planting other crops, especially cucurbits near the papayas. Affected trees should be removed. Do not allow papaya trees or any other unwanted vegetation to grow in the nursery vicinity.

11. INSECT TESTS

The following is a list of insects which can cause considerable damage. WARNING Do not use emulsifiable concentrate formulations on papayas as these cause leafburn. Use wettable powders only.

a) APHIDS AND WHITE FLY Infestation can become severe, especially white flies which have become a major pest in some areas. Malathion WP 25% at 4 lb/100 gallons every 2 weeks should give adequate control. However, if white flies persist another more specific insecticide is Applaud. Malathion WP 50% at 2 lbs/100 gallons is easier to handle.

b) FRUIT FLIES are a problem in some areas, damaging mature fruit. Spray Malathion and fruit fly bait on the underside of foliage of plants surrounding the field twice a week.

c) STINK BUGS Damage fruit while still forming inside the flower, scarring the new fruit. Spray Malathion at 4 lbs/100 gallons directed on to the newly exposed fruit, newly opened and unopened flowers every 2 weeks.

d) LEAFHOPPERS Bad infestation will leave the new growth bunched up, blotchy with translucent leaves. A sure identification is the presence of small drops of sap oozing from tiny pricks on the petioles where the insect has been feeding. Spray Malathion every two weeks, at the same rate, directed at the new growth. If leafhoppers and white flies persist, spray with Ambush WP or Lannate WP at recommended rates, twice at a weeks interval. It is advisable to spray a few trees first to test for damage, which should become apparent after 4 or 5 days. Watch the edge of the leaves for curling and the fruit for burn marks.

e) MITES Colonies of mites can be found along the ribs on the underside of leaves. Infestations can spread rapidly, especially in hot weather. Damaged tissue is easily noticeable, turning a light greyish/green colour before the leaf turns yellow prematurely. Mites can spread virus diseases. Apply Sulphur at 6 lbs per 100
gallons on the underside of leaves, to the run-off point. Repeat every 10 to 14 days until control is achieved OR spray Vehdex in a large volume of spray solution; apply at least 120 gallons per acre, at high pressure. Repeat after 12 or 14 days. For heavy infestations apply at the maximum rate. Good coverage is important.

WARNING: SULPHUR MAY BURN MATURE FRUIT AND LEAVES WHEN SPRAYED IN HOT, SUNNY CONDITIONS OVER 90°F (32°F)

Mites are among the most serious pests of papaya. Because of their minute size, the presence of mites is often not detected until well established. Check at least twice a week. In some areas a small black shiny beetle is an effective predator.

f) SCALES AND MEALY BUG can become serious at certain times of the year. Usually control of other insects will also control incipient mealy bug infestations.

Control with Malathion or Ambush. Most of the insecticides mentioned are compatible so can be included in the regular MANZATE (MANCOZEB) spray.

WARNING: Use spreader/sticker sparingly, at the lowest recommended rate, as spray deposits can accumulate at the tips of the hanging fruit and burn the skin. When MANZATE is being applied, do not use spreader/sticker. Control of weeds in the field and around the borders will reduce the incidence of insects. Remove dead petioles which hang on the tree. Many insecticides have a detrimental effect on papaya, Diazinon, Vydate, Corsban and Cygon, to mention a few. Do not use 2.4.D anywhere near a papaya orchard.

12. PLANT SELECTION OF SOLO TYPE PAPAYAS

It is necessary to wait until buds appear in order to identify the sex. Flowers will appear 3 to 5 months after planting, depending on the variety. 2/3 of all the trees planted will be hermaphrodites. Almost no male flowers will be found. One hermaphrodite tree per planting hole should be left. Start thinning as soon as the buds are large enough to be identified. This will be at about 1/2 to 3/4 inch long. Several passes through the field will be necessary. The hermaphrodite buds are the shape of an electric light bulb, the anthers readily visible on opening the flower. The female bud is rounder with no stamens. It is important to thin as early as possible. Trees left crowded together grow tall and spindly. It is desirable for trees to develop sturdy trunks and to bear fruit as low as
possible on the trunk. A good trunk gives room for developing fruit. When more than one tree per site is hermaphroditic, selection should be made on best appearance, thickest trunk, lowest flowers (a very desirable trait) and correct distance from adjacent plants. Cut trees being removed cleanly at ground level.

DETERMINING THE BASIC FLOWER TYPES OF PAPAYA

Perhaps you may have noticed healthy and vigorous papaya trees which flowers profusely but fail to get fruits or may even have small roundish fruits up to approximately 1 - ½ inches long, turning yellow and dropping off. This is a normal occurrence, if it is a female flowering (pistillate) papaya tree, because these small fruits which are really ovaries of female flowers probably have not been pollinated.

Pollination requires pollen from Hermaphrodite flowers and if this occurs, then a papaya develops and matures out becoming somewhat round in shape. Even if hermaphrodite flowering trees are growing nearby, they are not very good pollinators of female flowers. Because of this difficulty with pollination and because of the round, softball shaped fruits, and large seed cavities, female trees are usually considered undesirable.

Hermaphrodite papaya trees have flowers with both male and female parts and are usually consistent bearers of fruit because they are self-pollinating. These fruits are slightly more elongated than fruits from female trees.

When planting papaya seeds or seedlings, plants to establish at least three trees per planting hole. These plants should be allowed to grow until they reach flowering stage, since only after flowering can it be determined whether they are female or hermaphrodite or male. At this time, the trees can be sexed by looking at the flowers. Kilés (long pendulant branched inflorescence) and the female should be cut down. There are approximately two hermaphroditic plants to every female plant. Male flowering trees are practically nonexistent, having been selected out over many years of breeding.

<table>
<thead>
<tr>
<th>Female flower</th>
<th>Hermaphrodite flower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flowers rather large</td>
<td>Flowers tubular shape</td>
</tr>
<tr>
<td>Ovary present but no stamens</td>
<td>Have both pistil and stamen within flower</td>
</tr>
<tr>
<td>Five separate petals fused to one another at base of ovary</td>
<td></td>
</tr>
</tbody>
</table>

- 15 -
13. FRUIT THINNING AND MISSHAPED FRUIT

SOLO VARIETIES

3 fruit at each branch is the most the tree can produce of good quality. In very vigorous trees it is sometimes necessary to remove excess fruit while the fruit is still small, about 3 inches long. Sometimes "bunching" occurs on one branch and 1 or 2 fruit fail to develop. These should be removed to leave room for the good fruit. The aim is to avoid excessive packing round the trunk which can lead to many small, misshaped fruit. Fruit tends to become more packed around the trunk the older the tree becomes, when it is difficult to thin due to the height off the ground. Orchards equipped with tractor operated hydraulically controlled raised platforms for harvesting obviously are at an advantage.

The need to thin also varies with climatic conditions. This is true also of a problem called "Carpellody", which is the abnormal development of stamens into carpel like fleshy structures, the stamen becoming part of the fruit. The result is misshapen "cat-faced" fruit, which would probably be acceptable for processing, but is unmarketable. Carpellody appears to be influenced by environment and can cause serious periodical losses. No prediction can be made at this time on how serious this problem would be in Sri Lanka. Hot, dry conditions can produce sterile flowers.

14. HARVESTING

The first fruit of "Sunrise" Sole are ready to harvest at 10 months after planting in the field. The first month of harvesting will be light with some small fruit. For export, harvest when the blossom end is starting to turn yellow. For local market or processing, wait for a little more yellow development when about half the blossom end is turning yellow. Non refrigerated papayas will have a shelf life of about 6 days at prevailing temperatures when harvested early. Use plastic buckets for fruit receptacles and, if necessary, pad the edges to avoid bruising. When the fruit is too high to reach by hand rubber suction cups, about 4 inches in diameter, fitted with poles, can be used to remove the fruit from the tree, which is then allowed to drop into the harvesters hand. Picking from mechanical platforms makes the harvesting of fruit higher on the tree quicker, easier and less wasteful.
15. FRUIT SELECTION FOR SEED

Farmers should select suitable trees from which seed may be taken for future crops. These trees should bear fruit of desired size and shape, have few misshapen fruit, start bearing low on the trunk, at 3 feet is desirable, and have long stems to give the fruit more room to hang round the trunk. These trees should be marked. Flowers from these trees can be "bagged" prior to opening until after fruit development has started. This will ensure that the flower is self-fertilized and guarantee the purity of the variety. A commercial papaya enterprise will need to plant a new block of papayas every six months, so good seed should be available. Even so, it would be wise to import fresh seed every third generation. Fruit should be cut in half longitudinally for inspection before seed extraction. Any with abnormalities should be discarded. Also discard those fruit which have only a very narrow slither of meat between the seed cavity and the blossom end point. Fungal infection sometimes enters the seed cavity via this narrowed route.

16. WIND

Wind can have a positive effect on papayas by drying out the plants and discouraging insects. However, too much fruit causes fruit scarring, broken petioles and slows growth. Wind breaks may be necessary.

17. PAPAYA STORAGE

Papayas will suffer from chill injury whenever pulp temperatures drop below 48°F (9°C). Temperatures of 50°F - 54°F (10°C - 12°C) will keep the fruit from ripening and at 55°F - 57°F (13°C - 14°C) fruit will slowly gain colour and ripen.

Hydrocooling fruit in a 50°F (10°C) bath can be used to extract field heat prior to packing and storage, but "tunnel" cooling is usual. Cold room should be kept at 52°F (11°C) to prevent further ripening, if desired. At 56°F (13.5°C) the papayas will ripen slowly with a ¼ ripe fruit (yellow blush) turning to ¼ ripe in about 7 days. ¼ ripe fruit can be kept chilled for 14 days and allowed to ripen slowly for 7 days, giving a shelf life of 21 days from harvest.
18. **SEQUENCE OF ACTIVITIES FOR ESTABLISHING A PAPAYA ORCHARD**

- Select, clear and initially plough ground.
- Ensure irrigation equipment is on hand. Check water source.
- Prepare and plant nursery seed (5 weeks prior to planting).
- Rip ground, prepare beds.
- Irrigation in place, irrigate to germinate weeds.
- Place plastic mulch if used.
- Sterilise beds - Vapaam or Methyl Bromide (3 weeks prior to planting) or Terraclor through the drip system.
- Bury TSP (Triple Super Phosphate or substitute) at each planting site.
- Transplant 3 seedlings 6 inches apart in moist soil.
- Place Urea, Potassium fertilizer and other additives (as required) near plant.
- Irrigate every two days for ten days. Then twice a week.
- Spray with Malathion WP if insect damage is apparent.
- Replace dead plants as soon as possible.

**EQUIPMENT REQUIRED**

Assuming land preparation, ploughing and ripping, can be done by contractor.

- Orchard tractor for areas greater than 5 acres. At least 40 h.p (4 wheel drive optional but desirable)
- Disc type bedder, capable of throwing substantial beds.
- Sprayer - tractor operated air blast, high pressure sprayer with adequate tank capacity. Can be used on other orchard crops and be fitted with a boom for field crops.
- Trailer narrow enough to move down rows (6 foot wide). Preferably with low sides.

- Back pack hand operated sprayers for weed control and spraying young plants.

- Back pack motorised mist sprayers where a tractor sprayer is not available. Suitable for small areas only.

- Pick up/small truck

- Fertilizer injector for irrigation system.
TECHNICAL NOTES FOR BUSINESS PLAN FOR
MIXED FRUIT CULTIVATION INVESTMENT

1. THE FARM

The farming operation is best stared as a small, modest operation which will serve to provide only a small proportion of the raw material for the processing plant and thus could be described as part of the preliminary phase of the project.

While being optimistic in the long run, caution has to be exercised, as the high density, irrigated crops, will be grown using technology developed elsewhere, and farm development and production is expensive. Adjustments will have to be made and staff trained in new methods.

It is suggested that initially the following cropping plan be followed:

<table>
<thead>
<tr>
<th>Area</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Ha</td>
<td>Papaya</td>
</tr>
<tr>
<td>10 Ha</td>
<td>Pineapple</td>
</tr>
<tr>
<td>05 Ha</td>
<td>Passion fruit - A trial fruit to be sold locally</td>
</tr>
<tr>
<td>20 Ha</td>
<td>Guava</td>
</tr>
<tr>
<td>05 Ha</td>
<td>Banana &quot;Seed&quot; field</td>
</tr>
<tr>
<td>15 Ha</td>
<td>Other - road, nursery, building sites</td>
</tr>
</tbody>
</table>

---
| Total | 75 |

Passion fruit would be an experiment to test yields and survival time; whether the plants would bear economically in the third year. It is advantageous to have the information for future reference. Production could be sold locally.

Pineapples also should not be planted on a larger scale until more is known about yields in the farm environment. There are conflicting opinions about the suitability of the climate for maximum yields. Enough material will be generated to supply significant expansion if deemed worthwhile.

The farm would actually be a demonstration trial unit, and an administrative centre for the out-grower network. With cheap water and inexpensive land and labour, the long term outlook for the farm, as a profitable operation growing hi-value crops, must be good. With this in mind, when selecting a site, choose one that is twice the size of the present requirement of 75 Ha of usable land.
The farm building will have to be adequate to house machinery, temporarily store fertilizer and other inputs, and provide a work area when needed. Diesel pumps and at least a 1,000 gallon underground tank are needed and a workshop area. The Manager and other staff should be housed on the farm. Living away from the farm complicates management. This is an important point to keep in mind. The proposed buildings and machinery requirements are listed separately.

2. **IRRIGATION**

The crops will be irrigated with a low pressure drip system, although it may be necessary to use sprinklers occasionally. The vertical lift will never be significant, allowing reasonable running costs. It will probably be necessary to import the drip line (bi-wall or "T" tape) from James Hardy & Co., in Australia. This is a precision product which has only been perfected in the last few years. These systems work very well only if they are well maintained, by adequate filter capacity and constant attention. Capital outlay is high but operating costs low and the results should justify the cost.

Water consumption is low and easy to control, so that drainage is not impeded, and disease control is easier. Also a lot of the fertilizer can be applied through the system, as well as certain fungicides and nematicides.

The cost of the tubing, main, sub-main and laterals is included in each crop cost estimate. The cost of the pumping unit is included in the cost of machinery list. An unit mounted on wheels is recommended for flexibility. Not a permanent site with an expensive pump house.

3. **NURSERY DEVELOPMENT**

A large nursery will have to be started as soon as possible to grow mango, guava, passion fruit and raise papaya seedlings in plastic trays. Pineapple material should be multiplied in this area, but the banana seed field should be a separate entity. Follow the recommendations suggested in nursery guide.

A foreman, who also helps with the work, should be employed full time and be responsible to the manager. One of the functions of the nursery would be to supply planting material to the out-growers. This is an important long term goal; to build up an out-grower supply which may, in the end, render the farm redundant. The MARD nursery in System "B" should be able to provide technical assistance, including training.
The MARD nursery in System "B" will eventually be privatised. The possibility of taking over this nursery should be examined when the farm site has been chosen. The distance from the farm may be outweighed by the advantages, and the material available.

4. **PLANT MATERIAL**

The MARD mother nursery in System "B" will be able to provide pineapple, guava, mango and passion fruit planting material or bud wood.

Banana material will have to be purchased from existing plantations. A search would be conducted for the correct variety showing no disease symptoms and Nematode damage to the corms (tubers). The corms will be closely examined and treated in a hot water bath for 5 minutes at 120°F, prior to planting.

Further pineapple material (crowns) could be obtained from canneries.

5. **CULTIVATIONS**

Due to the small area to be cultivated initially, the expense of a tractor in the 80 h.p. range is not necessary. Two tractors in the 40 h.p. range with matching equipment, can do almost all the work required, and are most versatile for orchard crops. A local tractor will have to be hired occasionally for heavy ploughing, the cost of which is included in the crop cost estimates.

The land needs ripping in both directions to increase drainage and aeration. Do this before or after ploughing, whichever is easier. Chisel as deep as possible; if necessary, go deeper by increments.

6. **HARVESTING**

Existing machinery, small tractors and trailers, would be sufficient. However, boxes 48" square and 16" deep be used to contain the fruit to the processing plant. These would be lined with sacking or banana leaves as necessary. Close supervision will be necessary to ensure that all crops are handled with due care, and the workers educated in post harvest handling. Timely picking and transporting are essential.
7. **COMMENTS ON CROPS**

To be read in conjunction with cost sheets

**BANANAS**

- Leaf analysis values - 2.9% N Use the 3rd fully expanded leaf
  
  0.20% P leaf
  
  3.3% K

- The "Seed" Field is to be planted out one year in advance, the beds to be sterilized and the corms trimmed and treated with hot water to kill the nematodes. Careful supervision is necessary to avoid introducing nematodes into the seed area. The "Embul" variety is immune to Panama disease and resistant to Sigatoka leaf disease. (After Stover & Simmonds)

- From the agronomic point of view, bananas are reasonably easy to grow.

**PAPAYA**

Follow the growers manual

- Leaf analysis desirable range

  - N - 1% - 1.5%
  
  - P - 0.125% - 0.175%
  
  - K - 3.4%
  
  - Ca - 1.00% - 2.00%
  
  - Mg - 0.3% - 0.6%

- From the agronomic point of view, bananas are reasonably easy to grow.

**PASSION FRUIT**

- Pollination by hand will probably be necessary and, even when fruit are appearing, will raise yields.

- The orchard may only last 2 years before succumbing to disease, in which case the wire and trestles will probably be usable again. The crop has been costed out over three years. This would be a high risk crop, due to the unhappy experience of previous growers, either due to fluctuating prices or virus disease.

- Subsequent plantings must be made on fresh land.
Inter-cropping with vegetable is possible, with sufficient water (not too much). Do not plant melons, cucumbers and squashes as these harbour virus diseases. Do not plant creepers, such as sweet potatoes.

To start the nursery collect fruit from the best plants in an existing plantation. Thereafter select cuttings from the best plants in the orchard.

**MANGOES**

Fertilizer is important, especially in the early years, to allow the plant to make good vegetative growth. During the pre-fruiting stage keep adequately supplied with water. Inter-cropping is possible for first three years.

The fruiting sector in System "C" can be extended as much as possible by planting several varieties, maturing at different times during the season. Mrs Indrani Padmasiri has listed varieties of which grafting material is available in Sri Lanka. List attached. An attempt has been made to classify these varieties into early, medium and late maturing varieties. Obviously further research is needed in this area to plan on orchard, which will bear over a period of at least four months. A suitable mix of trees should be made available to the out-growers.

**Mango leaf analysis**

Desirable range -  
N - 1.0% - 1.5%  
P - 0.8% - 0.2%  
K - 0.3% - 0.8%  
Ca - 3.0% - 4.0%  
Mg - 0.15% - 0.40%  
Florida guidelines  
Use leaves from middle shoots

The cost of Rs 40/- (US$ 1.0) for seedlings is based on the prevailing price at government controlled outlets and private nurseries. The MARD nursery at Aralaganwila in System "B" is supplying for Rs 35/- each. It is very possible that a commercial nursery would contract to grow seedlings. The desired bud wood could be supplied to them, but careful supervision would be necessary.
PINEAPPLES

- In theory pineapples should grow well in System "B" & "C" but before embarking on an expensive commercial plantation this fact would have to be proved. Therefore trials should be run for at least three years to test yields. 10 hectares, divided into two or three blocks should be sufficient. Sufficient planting material should be maintained in the nursery to expand rapidly, if result warranted the cost.

- Pineapple leaf analysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Desirable Range</th>
<th>Smooth Cayenne</th>
<th>Puerto Rico</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1.6% - 1.9%</td>
<td>1.9%</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.16% - 0.20%</td>
<td>0.16%</td>
<td>0.20%</td>
</tr>
<tr>
<td>K</td>
<td>1.8% - 2.5%</td>
<td>Use the base of</td>
<td>2.5%</td>
</tr>
<tr>
<td>Mg</td>
<td>0.2% - 0.3%</td>
<td>the largest</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

- Floral induction must be used, using an Ethephon spray. A continuous supply then would be available year round. Pineapples could grow between the mango rows for the first 3 years, but not as part of the yield trials.

GUAVA

- If the soil where the intended orchard is to be developed is considered poor, the trees should be planted closer together, at about 22' apart. Plants always should be staggered in the row, allowing for one way traffic through the orchard. Closer planting would raise the cost slightly.

- Crop cycling - Should be practiced in order to ensure a good supply of fruit for most of the year, although, even with cycling this will vary. The principle was developed in Hawaii to harness the natural flowering tendencies of the guava. The concept is based on the fact that guava flowers are borne on new, succulent, vigorously emerging vegetative growth. Normally guava trees will respond to rains after a dry period with vegetative growth, flower development and subsequent fruit ripening time months later. The dry period actually triggers flowering, and in a climate with two dry seasons, two crops harvest seasons can occur. This natural tendency of the guava can be reduced, delayed or shortened depending on the weather.
Cycling is achieved by systematic manipulation i.e. pruning, fertilizing, irrigation and/or defoliation, to force the tree into vegetative growth. The recommended defoliant mixture consists of 100 gallons of spray solution containing 2 litres ethrel, 12 kg Urea and 1 litre of suitable surfactant. The procedure should be instituted immediately after harvest completion, or when the cycling is desired. A crop should be harvested about 7 months after cycling treatment, which should be Prune, Fertilize, Water, Defoliate. Cropping should cover a two month period. Therefore 6 blocks, in theory, should ensure a year round supply. 8 blocks would provide some overlap.

- Fruit fly may become a serious problem, which is controllable in a plantation by mechanical spraying. The extent to which out-grower crops would suffer is not known and therefore, a large enough area should be established on the nucleus farm to ensure a supply of the desired quantity of fruit.

- Guava leaf analysis

  Optimum value - 
  N - 1.70
  P - 0.25 Tentative value for Hawaii
  K - 1.5
  Ca - 1.25
  Mg - 0.25
  S - 0.18

- Cultivars - The following are available

  1. Beaumont (pink) - introduced by the FAO Horticultural project.
  2. Vietnamese (pink) local.
  3. Cultivar 11:56 - FAO project.
  4. Rudy Supreme Hybrid - FAO project.
  5. Two Australian processing types at MARD nursery.

These are all stated to be good processing types.
<table>
<thead>
<tr>
<th>Kg/Ha</th>
<th>Fertilizer Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T.S.P. @ Rs 497.50 50 kg</td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>PINE-APPLE</strong></td>
<td></td>
</tr>
<tr>
<td>1st crop</td>
<td>400</td>
</tr>
<tr>
<td>Ratoon crop</td>
<td></td>
</tr>
<tr>
<td><strong>PASSION FRUIT</strong></td>
<td></td>
</tr>
<tr>
<td>1st year</td>
<td>610</td>
</tr>
<tr>
<td>2nd year</td>
<td>300</td>
</tr>
<tr>
<td>3rd year</td>
<td>300</td>
</tr>
<tr>
<td><strong>PAPAYA</strong></td>
<td></td>
</tr>
<tr>
<td>1st year</td>
<td>1,400</td>
</tr>
<tr>
<td>2nd year</td>
<td></td>
</tr>
<tr>
<td><strong>MANGO</strong></td>
<td></td>
</tr>
<tr>
<td>1st year</td>
<td>100</td>
</tr>
<tr>
<td>2nd year</td>
<td>50</td>
</tr>
<tr>
<td>3rd year</td>
<td>50</td>
</tr>
<tr>
<td>4th year</td>
<td>50</td>
</tr>
<tr>
<td>5th year</td>
<td>50</td>
</tr>
<tr>
<td><strong>GUAVA</strong></td>
<td></td>
</tr>
<tr>
<td>1st year</td>
<td>255</td>
</tr>
<tr>
<td>2nd year</td>
<td>150</td>
</tr>
<tr>
<td>3rd year</td>
<td>150</td>
</tr>
<tr>
<td>4th year</td>
<td>150</td>
</tr>
<tr>
<td><strong>BANANA</strong></td>
<td></td>
</tr>
<tr>
<td>1st year</td>
<td>750</td>
</tr>
<tr>
<td>2nd year</td>
<td>100</td>
</tr>
<tr>
<td>3rd year</td>
<td>100</td>
</tr>
<tr>
<td>4th year</td>
<td>100</td>
</tr>
<tr>
<td>5th year</td>
<td>100</td>
</tr>
</tbody>
</table>
8. COSTS

A. PRODUCTION

PAPAYA
* Reputed to obtainable at low prices.
* Obtainable System "H".
* Easy for Out-growers to grow.
* Suitable.
  Farm Production - search for suitable varieties.

PASSION FRUIT
  Uncertain about yields.
  Trials only initially to be in position to increase rapidly if indicated.

BANANAS
* Grows well.
* Largest volume fruit crop in Sri Lanka.
  Obtainable but possible that price will be too high.
* Can increase production rapidly by keeping planting material on hand.
* Production costs reasonable. Disease free.

PINEAPPLE
  Yields and cost production must be tested - UNCERTAINTY.
  Trial for this purpose will ensure material.
  In hand for rapid expansion if indicated.
  Uncertain supply for processing plant.
  Growing Cost unfavorable compared to large scale commercial operations.

MANGO
* Local production increasing, but erratic production from bi-annual bearing.
* Planting progressing in System "B" procurement situation should gradually improve.

GUAVA
* Good prospects of production up to market capacity.
* Farm and out-grower production. Reasonable bearing in 4th year.
* Production scheduled easier controlled on farm/plantation.

GENERAL
* Out-growers can increase production if a market is reasonably sure.
B. MACHINERY

- 2 x Tractor 40-50 h.p. - e.g. MF 240  
  Rs 1,050,000

- Trailers (i) High platform 4' above ground  
  Size platform 5'x12'  
  Two wheeled (locally made)  
  Rs 84,000

- Trailers (ii) Gen. purpose 3 ton tipper

- 2 furrow reversible disk plough (one way if reversible not available)  
  Rs 90,000

- 1 chisel (ripper)  
  Rs 89,000

- 1 disk to hatch tractor  
  Rs 128,000

- 1 x ridger (for bedding)  
  Rs 86,000

- 1 x P.T.O. operated hi-pressure air blasts sprayer pump 275,000 capable of pressures up to 500 p.s.i. + modifications  
  Rs 40,000

- Fertilizer spreader (side dresser)  
  Rs 90,000

- Pick-up. 1 ton  
  Rs 550,000

- 4 x motor bikes (3 for extension agents) @ 35,000  
  Rs 140,000

- Trailer for the pick-up (low loader) - 12' or 14" long  
  Rs 80,000

US$

- Irrigation - Pump & motor  
  Rs 9,000  
  US$ 360,000

- Filter unit  
  Rs 500  
  US$ 20,000

- Fertilizer injector  
  (can be made locally - not necessary to import)  
  Rs 200  
  US$ 8,000

- Fittings, valves etc.  
  Rs 500  
  US$ 20,000

- Nursery - Based on MARD. Tank, permanent water system, permanent nursery sprinklers.  
  Rs 1,000  
  US$ 40,000

- Miscellaneous - Tools, scales, etc.  
  Rs 3,000  
  US$ 120,000

- Office equipment - computer  
  Rs 100,000  
  US$ 345,400

CONTINGENCY - 10%

US$ 345,400

TOTAL  
US$ 3,799,400
### C. BUILDING COSTS

<table>
<thead>
<tr>
<th>Description</th>
<th>US$</th>
<th>RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building costs -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30’ x 40’ store - 1200 sq ft</td>
<td>12,000</td>
<td>480,000</td>
</tr>
<tr>
<td>@ Rs 400 per sq.ft. - say Rs 4,350 per sq.m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof asbestos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple steel structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timber windows for vent and light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double doors - 10’ width to drive in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall - 10’ high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with infrastructure -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(office room + toilet - Rs 475)</td>
<td>2,250</td>
<td>90,000</td>
</tr>
<tr>
<td>+ extra Rs 75/sq ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dwelling house - simple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 1400 - 1600 sq ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1,500 @ Rs 550 = Rs 825,000)</td>
<td>20,625</td>
<td>825,000</td>
</tr>
<tr>
<td>@ Rs 500 per ft - may be up 10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 x Smaller houses (20’ x 25’ = 550 sq ft)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 x 550 + 550 = Rs</td>
<td>30,250</td>
<td>1,210,000</td>
</tr>
<tr>
<td>Store - (10’ x 10’) - earth floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel &amp; oils - @ 200 sq ft = Rs 20,000</td>
<td>500</td>
<td>20,000</td>
</tr>
<tr>
<td>Tractor shed (open, poles + C.I.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>= 18’ x 50 = earth floor @ 150 ft</td>
<td>3,375</td>
<td>135,000</td>
</tr>
<tr>
<td>Fencing, security + animal protection</td>
<td></td>
<td>200,000</td>
</tr>
<tr>
<td>Nursery Building - store 15’ x 10’) 25’x10’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- office 10’ x 10’) = 250</td>
<td>2,970</td>
<td>118,750</td>
</tr>
<tr>
<td>with infrastructure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTINGENCY - 10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,386,625</td>
<td></td>
</tr>
</tbody>
</table>

- 30 -
D. MANAGEMENT & STAFFING

The following staff would be adequate to operate the scheme

<table>
<thead>
<tr>
<th>Position</th>
<th>Experience/Qualifications</th>
<th>Rs/Month</th>
<th>Rs/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x Manager</td>
<td>University grad. 10 years experience</td>
<td>20,000+ 15%</td>
<td>138,000</td>
</tr>
<tr>
<td>2 x Supervisor</td>
<td>Ag. College grads or suitable experience</td>
<td>6,500+ 15%</td>
<td>180,000</td>
</tr>
<tr>
<td>1 x Nurseryman</td>
<td>Experience/train at MARD Project</td>
<td>6,500+ 15%</td>
<td>90,000</td>
</tr>
<tr>
<td>1 x Mechanic/Welder</td>
<td></td>
<td>6,500+ 15%</td>
<td>90,000</td>
</tr>
<tr>
<td>1 x Book-keeper</td>
<td></td>
<td>6,500+ 15%</td>
<td>90,000</td>
</tr>
<tr>
<td>2 x Extension workers</td>
<td></td>
<td>6,500+ 15%</td>
<td>180,000</td>
</tr>
<tr>
<td>2 x Watchmen</td>
<td></td>
<td>3,000+ 15%</td>
<td>82,800</td>
</tr>
</tbody>
</table>

850,800

The manager and supervisors must live on the farm and preferably the mechanic and book-keeper too, but so much depends on the availability of other housing.

TRAINING

It is essential that some arrangement be made for adequate training.

One option would be to send the proposed farm manager to the University of Hawaii. It may be possible to attach him to the extension service of the University of Hawaii. Two persons together, the manager and a supervisor would be better (could USAID assist?).

The farm would act as a training centre, which would be an ongoing, continuous process.

Cost Rs 75,000 flight to Hawaii + 90 days x $ 100 (expenses)
435,000
E. **COST OF FUEL TO IRRIGATE 1 HECTARE**

Cost operating drip irrigation

1 1/2 gallons diesel per hour to (20 acres papaya)

\[
4410 \text{ ft} \times 20 = 88,200 \text{ ft}
\]

\[
88,200 \times 0.4 = 350 \text{ g.p.m. (gallons per minute)}
\]

\[
\frac{100}{100}
\]

1 1/2 gallons for 350 g.p.m. \times 60 = 21,000 gallons water per hour

1 acre pineapple needs 8,820 bi-wall.

Therefore 1 1/2 gallons diesel per hour can irrigate

10 acres, applying 21,000

\[
\frac{21,000}{10} = 2,100 \text{ g.p. acre}
\]

Therefore \(1.5 \times \text{cost diesel} = 2,100 \text{ gallons per acre}\)

\[
\frac{2,100}{10}
\]

Amount water required to give 1" over 1 hec.

= 1 1/2 \times \text{c. diesel gallons} \times 61,000

\[
\frac{61,000}{21,000}
\]

**NB** Cost diesel Rs. 12.5/litre = US $ 5.50 per hect. inch
9. **RISKS & OPPORTUNITIES**

The farming operation faces some short term risks in that the yield and problems of intensive production are unknown. These are reduced by starting out with a small operation. No insurmountable problems, though, are anticipated, based on the experiences of other countries of similar climate. Once knowledge of the crops has been accumulated, expansion in the Mahaweli is almost a certainty. The farm shares the market risk with the rest of the business, but could diversify into other crops. E.G. Seed production.

In the long run a large scale farm must have a bright outlook with a good water supply, inexpensive labour and land and very few natural hazards, such as hail. As the economy slowly improves the internal market will expand. Sri Lanka is probably at the bottom of a long steady economic improvement phase.

10. **CHOICE OF SITE FOR NUCLEUS FARM**

A. **DRAINAGE**

The best terrain for fruit crops in the Mahaweli Systems is gently undulating land, giving sufficient slope to guarantee good drainage, during Maha. This is very important. The high water table mark should be at least three feet below the surface, preferably more, in the valley bottoms in wet weather.

Soil depth to bedrock is important, over 3', preferably more. All crops would be planted on beds or in the case of tree crops on raised mounds, to assist drainage, so the land has to be situated where there exists sufficient drainage capacity to allow water to flow freely away from cultivated areas. As a general rule the soils in Systems "B" and "C" become saturated rapidly, indicating that their natural drainage rate is slow.

Drip irrigation will reduce drainage problems, except in very wet weather. Choose as much land as possible above the water "command" level.
B. **SOIL**

Soil types are very mixed in the Mahaweli so it is probable that an extensive area would include different types. Provided these soils are not wet in the Maha all should be suitable for fruit crops. Some of course have better natural fertility.

The soil types in Section "B" range in pH values from 5 - 8. The former is too acid for most crops, but pineapples thrive at 5.5 (slightly acid). However, agricultural lime is available to rectify acidity problems, which will probably be highly localised. The higher values are suitable for all crops. A pH value of 6 - 6.5 is ideal. Very high pH soils can be productive using Sulphated fertilizers and micro-nutrients, which are available.

Not all land in one block will be suitable, or even cultivatable e.g. in Section "B", only about 60% of the land available in large blocks would be usable. The balance would be either too wet or too rocky. Salinity is reported to be a small problem in parts of System "."

In general, if soils are well drained, fertility problems can be solved. Many soil samples will have to be analysed and holes dug, to examine the profits to better understand the area. The organic content of the soils in these areas is very low, having been exposed to the sun over a long period. This can be rectified by growing leguminous green manure crops, such as Crotalaria, and using mulch and farm yard manure on the beds or round the trees. The soil must be protected from the sun.

A better organic matter content would help any drainage problems and improve fertilizer efficiency. As the crops develop, regular leaf samples should be analysed as a check on the fertilizer ratios. The Tea Research Institute have good facilities.

C. **WATER**

A guaranteed water supply, for irrigation, is necessary all year round, not just in the Yala. In the Mahaweli project area there are large tanks for storage while canals are closed for maintenance. As much ground as possible should be above the "command" water level, and water can economically be pumped long distances where there is little vertical lift. It may be possible to extend canals to bring water closer to the crops. Before making a commitment, check the water guarantee.
To drip irrigate 100 ha at one time a supply of at least 300,000 gallons/hour is needed. But it is unlikely that 100 ha would be irrigated at one time.

D. COMMUNICATIONS

Obviously the nearer to a paved road and power, the better, but the quality and suitability of the land should be the first priority. Some consideration may be given to the location of potential out-growers, but this would be more important for the processing plant site. Telephone communication is essential.

The site will have to be sited as near as possible to a source of labour, bearing the previous comments in mind.

E. CONCLUSION

After looking at the individual farms in System "B" and two in System "C", the latter area would seem the better choice. This has been confirmed in conversations with the local EIED Agronomy Consultants and others.

A contributory reason is a better available labour force. The road through System "C" to "B" is good, so out-growers in System "B" would fit conveniently into a nucleus farm in System "C". System "B" out-growers may become important as, being largely undeveloped, farmers will still have room to plant the types and varieties of fruit wanted by the processing plant.

11. SITE SELECTION

As to specific areas, land is currently available in three places, two in System "B" and one in System "C".

A. SYSTEM "B"

A large parcel of land is available North of Welikanda in the North of System "B". The area is at the moment under terrorist influence. Flooding is a problem in the Maha, although it is difficult to assess the extent as our visit was made in the Yala.

Three parcels are available in the S.W. part of System "B", just North of the boundary between "B" & "C" W.S.W. of Araleganwila. About 60% would be satisfactory for fruit growing, the balance too wet during the Maha. Canal water is abundant.
In System "C", blocks 409 and 410 have been reserved for large scale development. These are in the extreme North of "C" and adjoin the area of System "B" where land is available. Therefore these two areas can be considered as one. Any selection would be made on the factors mentioned previously.

However, the land further South in System "C" is preferable. Being slightly higher, the drainage problem is reduced or eliminated. The terrain in the vicinity of Girandurukotte looks well suited for fruit, the slopes more accentuated than the flatter area of System "B" and Northern System "C".

Also it is always an advantage to be near the services which a town provides. Only if it is impossible to obtain land in the Girandurukotte area, should the first three alternatives be considered. In general the soils of Systems "C" are better than "B", but any one parcel will have varying types.

When a final selection is to be made it is strongly recommended that the persons responsible fly over the area in a small plane to better understand the location.

B. OUT-GROWERS

In theory out-growers eventually should grow almost all the processing requirements, and this may happen in the very long term. In the short term, particularly during the preliminary phase, when all components of the project will be tested, consideration has to be given to what is actually practical and the mix between farm and out-grower production.

The preliminary plan calls for the following amounts of fruit for processing during the first phase.

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Amount</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papaya</td>
<td>1,500</td>
<td>In year one only a portion of this would actually be processed.</td>
</tr>
<tr>
<td>Mango</td>
<td>1,100</td>
<td></td>
</tr>
<tr>
<td>Pineapple</td>
<td>500</td>
<td>These figures would be needed for maximum production which would not be possible in year one.</td>
</tr>
<tr>
<td>Banana</td>
<td>2,500</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

To achieve an adequate quantity from out-growers in the future some goals should be established for a future date - perhaps 5 years after start up. By this time guavas on the farm will be in production and other crops established in quantities. The out-grower programme will have to be based on the assumption that the project will be successful.
Tentative quantities required may be approximate as follows:

<table>
<thead>
<tr>
<th>Fruit</th>
<th>M.T.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bananas</td>
<td>5,000</td>
<td>A large percentage from out-growers except for Guava.</td>
</tr>
<tr>
<td>Mango</td>
<td>2,200</td>
<td></td>
</tr>
<tr>
<td>Pineapples</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Papaya</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Guava</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passion fruit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

It would be easier to deal with the larger commercial farmers, those owning 25 or 50 acres, for obvious reasons. In Systems "B" and "C" there are 20 of these farmers on the ground, with 20 waiting to start. These would be sufficient for a start.

Mangoes and guavas could be an exception. The former would probably be scattered round the homesteads, and a large part of the latter will probably be produced on the farm, where control of cycling and fruit fly will be easier.

Quality control would be controlled by frequent visits to ensure the farmer knows exactly what to do, and harvest is timely and co-ordinated. Particular attention will have to be paid to post harvest handling. Harvest boxes, 48" square x 16" deep are commonly used. These are designed for stacking, if necessary, and could be cushioned with sacking, banana leaves etc.

Extension workers would have to be based on the farm, and be responsible to the farm manager. Each would have a motor cycle and be able to handle about 20 out-growers. This allows him to spend a day with each one every month. Graduates from the Ag. School at Peradeniya should be sought for this work, and an allowance made for some initial training, probably with the company that is running a successful out-grower programme with Gherkins.

C. VISIT TO SYSTEM "C" - 26 - 29 JULY, 1991

The object was to identify two or more parcels of land suitable for the fruit production farm in System "C", according to the term of reference.

All parts of System "C" were visited, special attention being paid to the areas available for large scale cultivation, marked 1 to 10 on the map of System "C" attached. This map was obtained from the EIED office in Colombo. A trip was also made to Bibile, South of System "C", to get a comparison of the two areas.
a) In the South Section 201, in Zone 2, comprising 600 ha, is available for commercial farming. Marked 9 on map. The land is very broken, sharply undulating with short slopes descending often to eroded gullies. Rocky outcrops are numerous, but irregular. There are no water canals in this area and none planned, therefore tube wells would have to be sunk for irrigation. This is in fact the policy of the Mahaweli Authority, their thinking being that large scale operations can supply their own water, leaving the canal water for settlers. Some parts of this section could be used, especially the Western part, but fields would be small due to the broken terrain, and water development expensive.

A large labour pool exist in Mahiyangana. Some moderate to heavy clearing would be necessary.

b) On the Eastern side of Section 201, there is a strip of land running along the South West shore of Uhlitiya reservoir, marked 10 on the map. Most of this area has been taken up by C.T.C. (partly planted with passion fruit), but 102 HA is available at the Northern end. This land was originally allocated to Food and Beverages who subsequently relinquished it. Water would be available from the reservoir, but this point would have to be made very clear with the MED and EIED before any commitment was made. This land is also broken with short ridges, gullies and rocky outcrops. The cultivatable area would be suitable for fruit crops, but the 100 ha available will probably yield 60 or 70 ha of farmable land. This tract would be useful as a start, but puts a severe constraint on expansion. If the first phase was successful expansion into the rest of block 201 may be possible later, if the land was still available. This is a risk that may not be acceptable. Water could be drawn from the reservoir. Some moderate clearing would be necessary.

c) 127 HA available, in block 409, 2 - 3 km due North of Dehiattakandiya. The land in this area is gently undulating, the natural drainage lines running approximately South to North. This leaves long unbroken ridges gently sloping down to the drainage lines. Rocky outcrops are few in this areas and the soil depth good. Construction of irrigation ditches is proceeding in the area, leaving a visible soil profile up to 5' deep in places. Very little gravel was observed. Most of the land is completely open, indicating that it has been grazed, and probably burned, over many years so only moderate clearing would be necessary. The ridge tops are about 15 feet above
tank water levels particular piece of land. This (see contour lines on the map of F.C.L. 127 Ha) would be very suitable for a farming operation, such as envisioned, about 80% of the land being well enough drained for permanent fruit crops.

The irrigation distribution canals are still under construction in this area and the two tanks indicated on the map are not yet full. Tank no 1 will probably be full by the end of 1991 and no 2 sometime in 1992. The land is actually under command as the general slope of the land is from South to North, and a canal no 1/410, not yet constructed, is due to be built in the near future. This will cross the block near its highest point. At the moment EIED say the they will allow canal water to be used for irrigation if the project is important enough. A good case can be established to use the Mahaweli water, especially as drip irrigation only will be used, making far more economical use of this resource.

This land has advantages over the other two pieces mentioned. Apart from being easier to work, it is very near a township and about 1 mile from electricity, with easy access over flat land. The Mahaweli Authority is constructing houses in the vicinity, and so the power grid will probably spread rapidly. It is centrally located for easy access to System "B", simplifying outgrower operations. Mr Sunil Epasinghe, the EIED Deputy Manager in System "C" says that Dehiattakandiya is developing at a faster rate than Girandurukotte and will eventually be a bigger township. The main MEA offices are located in Dehiattakankiya.

These advantages make this piece of land the obvious choice, and every effort should be made to establish the farm here, and not in the South.

d) A trip was made to the extreme South of System "C" (not under EIED control) and on to Bibile. South of System "C" the land along the roadside is populated but there is no organised irrigation and away from the houses the land looks very dry and unproductive and in places hilly. Rainfall increases near Bibile, but very little irrigation was observed; only small patches from local streams. Nothing was seen to alter System "C" as the best farming area - given the water.
D. **SOIL FERTILITY AND FERTILIZERS**

The following comments are a result of conversations with Dr Seneviratne, the soil chemist at the Ag. Research Institute at Kandy, Dr Sunil Dimantha of The MEA land use division, the Huntings Technical Institute report on System "C" soils, dated 1979, conversations with other people and observations.

The natural fertility of the soil is low. System "C" comes entirely within the Red Brown Earth soil "great" group. This is broken in the valley bottoms and natural drainage ways by Humic low gleys which have been affected by a fluctuating water table over the years. Some soil analysis, results, mechanical and chemical, are attached. Salinity is not a problem. There is some variation but nothing to cause concern. When work actually starts on a specific site separate soil samples should be taken from each field. In general Red, Brown earths are well drained but have poor surface structure and a high degree of differentiation of the clay contents within the profile. Gravel layers occur and can impede drainage. The surface structure can be improved by ploughing in green manure crops, mulching with grass and mixing farm yard manure into the soil. The poor structure is related to the poor water carrying capacity of this soil. These soils become saturated quickly and dry out rapidly. Therefore it is necessary to water little and often; every two or three days with drip irrigation. The same principal is true for fertilizers, apply little and often to obtain maximum benefit.

Although the natural fertility is low no minor element deficiencies are anticipated. The pH values are almost ideal and the parent rock contains these elements. When pH values are too high or low minor elements can become unavailable to plants. It is reported that available Potassium is usually sufficient in these soils. Organic contents of all samples are low, but this can be rectified, as discussed, with green manure crops, grass mulch and manure. Nitrogen and Phosphate are relatively cheap to apply. The only problems that may occur are imbalances caused from applied fertilizers, many years after start up, and can be corrected by using leaf analysis results as a guide.

Therefore the main criteria for choosing a farm site in System "C" are:

1) Depth of soil sufficient for a good root system.
2) **Drainage** - free drainage, excess water having somewhere to go.

3) **Slope** - erosion is difficult to control on steep slopes. These soils have high sand to clay ratios and therefore are vulnerable. A gentle slope is sufficient for adequate drainage.