# FINAL REPORT

## TECHNICAL AND ECONOMIC EVALUATION OF NEW TECHNOLOGIES INTRODUCED BY THE INTERNATIONAL SERVICE PROVIDER FOR FRUIT AND VEGETABLE CROP SECTORS UNDER THE ASMP AGAINST THE EXISTING TECHNOLOGIES

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**Submitted By**

MG CONSULTANTS

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# Technical and Economic Evaluation of New Technologies introduced by the International Service Provider for Fruit and Vegetable Crop sectors against the Existing Technologies

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விவசாய நவீனமயமாக்கல் திட்டம்
Agriculture Modernization Project

## Executive Summary

This study was conducted to compare New Technology (NT) packages against Existing Technology (ET) for Cavendish and Ambul Banana and Guava and assess technical and economic superiority of the NT packages introduced and completely implemented by the ISP under the ASMP and to make recommendations to promote these technology packages beyond the ASMP crop clusters. The study was conducted through desk studies, discussions with project staff and field officers and interviews with farmers who were engaged in adopting the NT and ET for the above crops. The set of Operational Manuals produced by the ASMP comprehensively describes the technical information for cultivation, harvesting, processing and marketing, which was not available hitherto for the Sri Lankan farming population. Some of the key highlights introduced in the operational manuals and the field implementation program are the double row planting, the box method of pruning and the Espalier Trellis and Pruning system. All these improved technologies are new introductions to the horticultural sector of Sri Lanka. The farmers agreed that the NT has enhanced their income through increased yield of all the crops considered, while the enhanced benefits are proved by the financial and economic analysis conducted. The superiority of the technical recommendations of NT over ET is directly reflected in the FIRR and cost-benefit ratio given in the report. The following narration summarizes the findings of the study.

### Guava

Of the given two varieties, the White guava variety is popular and all the interviewed farmers (100%) have grown White guava. Mostly, farmers grow guava using air layering plants but under the NT, they have used seedlings with the guidance from ASMP. According to the farmers, air-layering plants start flowering 03 months after planting, earlier than the initial flowering of seedling plants.

All the interviewed farmers (100%) have practised double-row planting and they appreciated this practice because they could increase their harvest and income owing to the increase in plant density. Plant density with NT is 1100 plants per acre compared with 600 plants per acre with ET.

Farmers have acquired the pruning technology for guava, resulting in an increase in harvesting frequency and the volume of harvest. Farmers were practicing the box pruning method before introducing the Espalier Trellis and Pruning system. Farmers assured that the Espalier Trellis Method and pruning increases the yield of a plant compared to box pruning. They observed that the Espalier Trellis method prevents mutual shading of branches within the plant while the box pruning system cannot prevent mutual shading of branches. Therefore, the bearing is higher in ET system compared to the box pruning system. The ASMP has provided free to each cluster farmer the material required for constructing an ET system for a half-acre or a quarter-acre. After experiencing its benefits, farmers expressed that they would construct ET system for the rest of the guava cultivation themselves. Also, it is worth mentioning that framers practice de-blossoming and bagging of fruits as recommended in NT.

The NT with sprinkler irrigation have reduced the average quantity of water utilised annually to irrigate guava cultivation to 724,992 lit from 1,152,000 lit for ET per acre. The average annual labour used for irrigating an acre of guava cultivation decreases from 60 to 22.3 man-days with the adoption of NT as against ET. As a consequence of a reduction in man-days required for irrigation, the cost of labour required for irrigation has also reduced from Rs. 150,000/= to Rs. 55,750/= per acre per year for NT.

The NT has resulted in the reduction of annual energy cost for irrigation from Rs. 80,000/= for ET to Rs.

42,237/= per acre for NT. This reduction in the cost of energy is mainly due to a reduction in the amount of irrigation or a reduction in the time of irrigation. Farmers can get this energy cost reduced to zero by using solar panels provided by the ASMP.

Farmers reported on the ability to reduce the quantity of fertilizer used for NT to 371 kg per acre per year from 1200 kg for ET. Corresponding to the reduction in fertilizer quantity, the cost of fertilizer also decreases from Rs. 216,000/= for ET to Rs. 145,590/= per acre per year for NT. The labour requirement for applying fertilizer decreases from 24 man-days for ET to 22.5 man-days per acre per year for NT. However, farmers accept that they applied fertilizer more than enough and they sometimes tend to manually apply fertilizer while fertigating.

Average annual guava production with NT increases from 2,060 kg per acre in the first year to 36,400 kg per acre in the fifth year while with ET, it increases from 500 kg per acre in the first year to 14,000 kg per acre at fifth year.

Guava production is categorized into two grades based on size, appearance and damages. Grade 1 guava is bought at a higher price. The price considered is Rs. 400/= per kilo for grade 1 and Rs. 100/= per kilo for grade 2. As the interviewed farmers report, about 86% of total production is grade 1 and about 14% of the total production is grade 2 with regard to NT.

As the interviewed farmers reported, their gross annual revenue varies from Rs. 0.74 million per acre in the first year to Rs. 13.02 million per acre in the fifth year with NT. Under ET, average gross annual revenue varies from Rs. 0.198 million per acre in the first year to Rs. 5.544 million per acre in the fifth year. This clearly shows that NT is far superior to ET.

The average costs of production for grade 1 guava and the total cost of production for guava production based on five years are Rs. 146/= per kilo and Rs. 126/= per kilo respectively with NT. However, the average costs of production for grade 1 guava and total guava production based on five years for ET are Rs. 330/= per kilo and Rs. 323/= per kilo respectively. The cost of production of all the above is lower compared to the current market price of Rs. 400/= per kilo for grade 1 Guava. The current market price for grade 2 guava which is Rs. 100/= per kilo is lower than the above cost of production figures.

The cost of production for total production and grade 1 guava production with NT has decreased over the years. The cost of production of total production for years 2, 3, 4, 5 and 6 are Rs. 666, 224, 118, 107, and 90 per kg, respectively, with NT. With regard to grade 1 guava production, the cost of production for years 2, 3, 4, 5 and 6 are Rs. 773, 260,137, 124, and 105 per kg, respectively with NT.

In the case of ET, the cost of production of total production for years 2, 3, 4, 5 and 6 are Rs. 3,347, 728, 462, 262, and 138 per kg, respectively. With regard to grade 1 guava production under ET, the cost of production for years 2, 3, 4, 5 and 6 are Rs. 3,415, 743, 471, 267, and 140 per kg, respectively. Accordingly, the cost incurred in producing a kilo of guava under NT is reduced as compared to ET. Further, the time required for covering the cost of production or breakeven point is reduced with NT to the third year from the fifth year with ET.

The FIRR for an investment in guava cultivation with NT is 94% while for ET, it is 14%. These FIRR values indicate that an acre of guava cultivation with NT generates benefits at a higher rate (94%) to a beneficiary than that with ET (14%). The present value (at 8%) of net worth generated by an acre of guava cultivation with NT is Rs. 15.38 million per annum while for ET, it is Rs. 0.613 million per annum. The benefit-cost ratio regarding NT is 262% while for ET, it is 109%. According to these value criteria, guava farmers can increase their benefits by adopting the new improved technology compared to the existing technology.

The EIRR for an investment in guava cultivation with NT is 93% and for ET, it is 15%. The EIRR values indicate that an acre of guava cultivation with NT generates benefits at a higher rate (93%) to the whole economy than that with ET (15%). The present value (at 8%) of net worth generated by an acre of guava cultivation with NT is Rs. 11.13 million per annum to the whole economy while that with ET is Rs. 1.49 million per annum. The benefit-cost ratio regarding the new technology is 263% while it is 110% for ET. According to these values criteria, guava cultivation can increase the benefits for farmers and GDP of the country by adopting the new improved technology compared to that with the existing technology.

While the high intensity double row planting system increases the plant population, it results in increased yield and production. The Box Pruning method for guava increases the number of flowering and fruiting points while giving more access for farmers to reach the inner spaces of the plant architecture to reduce the shading effects of each other branches. However, the space occupied by each plant is higher as compared to the Espalier method. In contrast, the Espalier Trellis Pruning method gives the farmer the highest access to every point of the plant while further enhancing the flowering and fruiting points. Within the Espalier System, the space occupied by each plant is minimised as it occupies only the vertical space, unlike in the box system where the plant occupies horizontal space. This gives an advantage for the Espalier System to capture more sunlight to utilize for fruit production. In conclusion, it is stated that the new technology introduced by ASMP is superior to existing technology with respect to technical and financial aspects that had been studied.

### Banana - Cavendish

With respect to quality-enhancing technology, all of the interviewed farmers (100%) adopt bunch clearing before and after bagging, bagging, tagging and propping while 80% practice de handing with fish line and de-latexing as they sell their product to the packing centre. They agree that the said practices will improve protection for fruits from sunburn, hot wind and dust, enable avoidance of fungal diseases, and reduction of abrasion injury for fruit skin. According to farmers, they have been able to improve the appearance and quality of Cavendish banana by adopting these practices of quality enhancing technologies.

All farmers (100%) responded uniformly that they adopted the use of tissue cultured plants, deep ploughing with MBP, disking and harrowing, and application of compost. Only 80% responded that the second deep ploughing was conducted while only 60% agreed that micro-levelling and formation of drainage canals are important but Laser Levelling has not been performed with any farmer. Fertigation was practised with chemical fertilizers within the first 6 months by 40% and for 9 months by 60% but no organic liquid compounds were used. Farmers did not practice fertigation as they thought that a sufficient quantity of fertilizer could not be applied through fertigation. Only 80% have reported about adopting intercrop cultivation but that also they practiced only once.

Data gathered from farmers show that a mini sprinkler irrigation system for Cavendish consumes an average annual volume of 2,331,225 litres of water for 0.5 ac. The average annual labour used for irrigating Cavendish cultivation under the sprinkler irrigation system is negligible because farmers just have to operate sprinklers. In comparison, ET, as practiced by farmers, uses flood irrigation, requiring diverting water from an irrigation canal or pumped water where they have to attend for irrigation with manual labour. The average annual amount of labour used to irrigate Cavendish through flood irrigation is 80 man-days under ET.

The quantity of fertilizer used under ET is almost 65% as for NT per 0.5 ac per year. Similarly, the average annual fertilizer cost also reflects an identical figure of 62%. Some farmers still believe that manual application is superior to fertigation with respect to the availability of nutrients to individual clumps. The average annual labour used for applying fertilizer for 0.5 acre under NT and ET is around 21.5 man-days and 15.5 man-days, respectively while the cost of labour reflects around 60%.

The average annual production of Cavendish banana per 0.5 ac under NT is higher than ET, primarily due to the new method of double row planting pattern that increases the plant density. Plant density under NT is around 480 plants per 0.5 acre.

Average annual Cavendish production with NT increases from 3,873 kg per 0.5 acre in the first year to 8,597 kg per 0.5 acre in the third year and stabilises onwards. In comparison, the yield with ET increases from 1050 kg/0.5 ac in the first year to 3900 kg/0.5 ac in the second year and thereafter, the harvest is constant. The average annual income from Cavendish banana varies from Rs. 372,226/= to Rs. 846,641/= for NT while for ET, the income varies from Rs. 197,400/= to Rs. 733,200/= per acre.

The cost of production of Cavendish with NT is estimated to be Rs. 209/kg in the first year and thereafter, it is reduced to Rs. 80/kg in the second year and Rs. 78/kg in the third year and onwards. The cost of production with ET is Rs. 257/kg in the first year and Rs. 57/kg in the second year and onwards. The lower cost of cultivation with ET in the subsequent years results in a lower breakeven market price for ET than NT, giving the advantage to farmers with ET in the local market. Farmers who adopt the new technology cannot exist when the market price is less than Rs. 80/kg. However, farmers who adopt the existing technology can exist when the market price is less than Rs. 80/kg. The Price offered at the processing centre for Cavendish banana with NT varies from Rs. 112-120 per kg, while even for banana with ET would fetch a similar or slightly lower price. Farmers supplying NT banana for the Processing centre have to transport the bunches to the centre which adds further cost to the final product.

FIRR for an investment in Cavendish cultivation with NT is 33% while it is 94% with ET. These FIRR values indicate that 0.5 ac of Cavendish cultivation with NT generates benefits at a lower rate (33%) to a beneficiary than for ET (94%). The present value (at 8%) of net worth generated from 0.5 ac of Cavendish cultivation with NT is Rs. 0.2379 million per annum while with ET, it is Rs. 0.6733 million per annum. The benefit-cost ratio for NT is 112% while for ET, it is 143%. According to these values criteria, Cavendish farmers do not gain advantages by adopting NT as compared to ET. According to the survey, both NT introduced by the ASMP and ET for Cavendish banana are financially viable. NT can increase yield compared to ET but the cost of production of Cavendish banana with the new technology is greater than that with existing technology.

Irrespective of the technology, interviewed farmers observed that the market price is not sufficient to cover the cost of production. One approach to reduce the cost of production would be to use solar energy for pumping. Also, the cost of fertilizer application can be reduced by precision fertilization.

### Banana - Ambul

All farmers have adopted bunch clearing, bagging, coloured tagging of bunch, harvesting by de-handing, de-latexing in the field, and transport to packing centre while no farmer adopted propping and guying believing that Ambul stems are strong enough to withstand the weight of the bunch. Only 60% believe that bunch clearing will help reduce diseases, insect damage and abrasion injury. Around 80% was uncertain whether bunch clearing before bagging would help in yield increases, better appearance and reducing fungal diseases.

All farmers adopted recommendations by ASMP on peeper planting, deep ploughing, application of compost, disk harrowing, micro levelling manually, precision planting, and double row high density planting while only 20% adopted the use of mini-sprinkler irrigation systems. They were not aware of laser Levelling. Only 40% adopted intercropping and fertigation, of which only 20% have applied chemical fertilizers for up to 09 months. Farmers believe that it is not possible to apply adequate fertilizer through fertigation. None of the farmers adopted IPM practices.

The volume of water used to irrigate Ambul banana in Rajanagana with NT is slightly higher than that with ET. The average annual volume of water used to irrigate 0.5 acre with NT is 2,612,533 litres, compared to 2,400,000 litres with ET. However, the quantity of water use is compounded by the fact that farmers of both NT and ET have access to free flowing canal water. Farmers tend to practice flood irrigation even with new technology as they can divert water from the canals of Rajanagana reservoir without a cost.

The cost of energy incurred in irrigating banana cultivation by existing farmers is zero as they divert water (flood irrigation) from irrigation canals of Rajanagana reservoir. The energy costs of NT can be reduced to zero with the operation of solar panels which had not been provided within the first two years.

Thus, the average annual labour used for irrigating 0.5 ac of Ambul banana under NT with the sprinkler irrigation system is 25 man-days while it is 16 man-days under ET. Similarly, the cost of labour with the new technology is Rs. 75,250/= and that with the existing technology is Rs. 48,000/=.

The quantity of fertilizer used under NT is 885 kg per 0.5 acre for a year while under ET, it is 270 kg per 0.5 acre for a year. The average annual fertilizer cost under the new technology and the existing technology for 0.5 ac of Ambul banana cultivation is Rs. 172,612/= and Rs. 50,428/=, respectively.

The average annual production of Ambul banana per 0.5 acre with the practices of NT is higher than that with ET practices over a year. The Double row planting pattern of the new improved technology which increases Ambul banana plant density is directly linked with production increase. Plant density with NT is 450 plants per 0.5 acre while that is 375 plants per 0.5 acre with ET.

Average annual Ambul banana production with NT increases from 5,012 kg per 0.5 acre in the second year to 9,604 kg per 0.5 acre in the third year onward. Under ET, Ambul banana production starts in the second year and is 5,500 kg per 0.5 acre per year and remains constant over the next several years.

The average weight of a bunch of Ambul banana is 12 to 15 kg. The average annual income from Ambul banana with NT varies with the market price offered from Rs. 50/= to Rs. 150/= per kg. Therefore, the reported average value of the harvest is Rs. 479,640/= in the second year and Rs. 1,272,200/= in the third year and onwards. The average value of Ambul banana production with ET is Rs. 220,000/= per year and remains the same over the next few years.

Rajangana farmers can earn Rs. 100,000/= per year with the new technology by selling plants produced in 0.5 acre of Ambul banana in addition to selling bunches while they can earn only about Rs. 4000/= per year with ET by selling plants. With the new technology, double row planting pattern and sufficient fertilizer application, they can produce more plants than with the existing technology.

The cost of production of Ambul banana with NT is Rs. 235/= per kilo in the second year and thereafter, it is Rs. 48/= per kilo from the third year onward. The cost of production with ET is Rs. 42/= per kilo in the second year and Rs. 16/= per kilo from the third year onward. Except for the first year, the cost of production with ET is lower than that with NT. Farmers who adopt ET have a lower breakeven price compared to NT, owing to lower COP. Farmers who adopt the new technology cannot exist when the market price is less than Rs. 48/= per kilo while farmers adopting the existing technology can survive even when the market price is less than Rs. 48/= per kilo.

FIRR for an investment in Ambul banana cultivation with NT is 72% while for ET, it is 91%. These FIRR values indicate that 0.5 acre of Ambul banana cultivation with NT generates benefits at a lower rate (72%) to a beneficiary than that with ET (91%). The present value (at 8%) of net worth generated from 0.5 ac of Ambul banana cultivation with NT is Rs. 2.0113 million per annum while for ET, it is Rs. 0.3622 million per annum. The benefit-cost ratio regarding NT is 200% and that for ET is 178%. According to these value criteria, Ambul banana farmers do not gain advantages by adopting NT compared to ET.

According to farmers, although investment costs and quantities of inputs are high under NT compared to ET, precision fertilizer application can increase the efficiency of fertilizer application and reduce the cost of production per kg while reducing the environmental problems caused by excess quantities of fertilizer.

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## 1. Brief Description of the Project:

The Agriculture Sector Modernization Project (ASMP) is implemented with the following Project Development Objectives:

- To support increasing agricultural productivity,
- Improve market access and
- Enhance the value addition of smallholder farmers and agribusinesses in the project areas.

The Project is comprised of three components.

Component 1: Promote commercial and export-oriented agriculture through Agriculture Value Chain Development

Component 2: Support smallholder farmers to produce competitive and marketable commodities, improve their ability to respond to market requirements and move towards increased commercialization.

Component 3 Focus on human resource management, capacity building, logistic requirements, monitoring and evaluation, communication and coordination of the overall Project.

Implementation of component 2 undertaken by the Ministry of Agriculture, started in 2017 with the funding from World Bank of USD 64.23 Mn to implement the project in seven districts (Jaffna, Mullaitivu, Anuradhapura, Polonnaruwa, Batticaloa, Monaragala and Matale) of five provinces namely Northern, North Central, Eastern, Uva and Central. In 2021, component 2 was further supported with co-financing from the European Union, USD 23.3 Mn, to implement the same project concept in 5 additional districts (Kilinochchi, Vavuniya, Ampara, Badulla and Kandy) in the same provinces selected before.

Listed below are the sub-components of Component 2 of the ASMP:

A. **Farmer Training and Capacity Building:** Under this Sub-component, institutional development and related capacity-building activities are carried out to establish and empower Farmer Companies (FC) in each crop cluster established by the project.

B. **Agriculture Technology Demonstration Parks (ATDPs):** This is the main sub-component of Component 2 of ASMP. A minimum of three crop clusters per district had been selected, and the design, establishment and continuity of crop clusters were ensured. Each member farmer of a crop cluster was a member of the Farmer Company (FC) and received a technology package as a grant. In addition, farming-related collective assets, certain technical exposure visits, technical training and awareness and specific technical consultancies were delivered.

C. **Production and Market Infrastructure:** Under this Sub-component, cluster /ATDP-specific market infrastructure, such as common agro-processing/collection centres, identified market access roads and compost-making units, required irrigation infrastructure and any other specific supportive infrastructure facilities were established.

D. **Analytical and Policy Advisory Support:** Related policy studies, as well as required analytical studies, were carried out under this sub-component. In addition, certain related assessments /evaluations were conducted, Techno Forums were organised, Policy Forums, and formulation of Policy /Strategy briefs /guidelines was carried out.

This consultancy assignment was included under Component 2.

## 2. Project Management:

The Ministry of Agriculture and Ministry of Plantation Industries implemented and managed the project activities through the Project Management Unit (PMU) of the ASMP in Colombo together with the Provincial Project Management Units (PPMUs) with the support and guidance of the Provincial Ministries of Agriculture and other relevant stakeholders.

The Project is technically steered and monitored by the National Project Steering Committee headed by the Secretary to the Ministry of Agriculture. Respective Provincial Steering Committees are headed by the Chief Secretary of each Province.

## 3. Background for the Assignment

The Agriculture Sector Modernization Project employed an International Service Provider (ISP) to implement Agriculture Technology Demonstration Parks (ATDPs) with modern technology, the sub-component B of Component 2.

The ISP, FCG-ANZDEC Ltd of New Zealand, was given the assignment to establish, operate and hand over ATDPs in seven project districts. Each ATDP consisted of a minimum of three crop clusters with necessary infrastructure facilities. The ISP selected high-value fruit and vegetable crops with potential export & domestic markets to be grown in these crop clusters with modern technology. In selecting crops, fruit crops with Low Hanging Fruits were given priority. The crop clusters were either fruits or vegetables. In some of these crop clusters, a complete technology package has been implemented by the ISP, and the farmers had completed harvesting one or two crop cycles, whereas in other crop clusters, technology packages were not completely implemented by late 2024.

One of the focuses of the ASMP was to introduce new technology packages to the agriculture sector with marketable high-value crops and improve their productivity by using modern technology.

Therefore, it is necessary to evaluate the technical superiority and economic viability of the new technology packages introduced by the ISP.

## 4. Main Objective of the Assignment

The main objective was to carry out an in-depth technical and economic evaluation of completely implemented new technology packages, introduced by the ISP under the ASMP, to make recommendations to promote these technology packages beyond the ASMP crop clusters.

## 5. Specific Objectives of the Assignment

1. To identify the technical superiority of the new technology packages over the existing technologies

2. To analyse financial gains to the farmers and economic gains to the country by adopting the new technology packages
3. To identify any policy and regulatory gaps that need to be addressed to promote new technology packages beyond the ASMP crop clusters.

## 6. Methodology of Data Collection

Primary and secondary data were used in this assignment. Primary data were collected from the farmers who used the new technology package as well as those who used existing technologies. Secondary data included data regarding available policies related to the new technologies and price data.

The literature survey conducted included Operational Manuals of various crops.

Primary data collection was conducted by interviewing selected farmers who used new technology packages and who used existing technologies. They were interviewed using a structured questionnaire. In addition, key informants such as relevant officers from the public sector and private sector (export companies) were interviewed using a relevant format. Secondary data was collected by reviewing relevant documents such as project reports.

### 6.1 Sample Selection

A set of farmers who had used the proposed technology package to a reasonable extent were selected for the survey. The sample was purposively selected relevant to each crop considering the variation of the extent cultivated, geographical situation, water availability, climatic conditions, etc.

The number of farmers to be interviewed based on crops, district and technology was 77 as shown in Table 1, below. Out of the total number of 77 farmers, 55 farmers were expected to use new technology and the other 22 farmers were to be taken from the users of existing technology.

Table 1Proposed sample of farmers:

| Crop | Location | Farmer | |
|---|---|---|---|
| | | NT | ET |
| Cavendish | Sevanagala | 5 | 2 |
| | Vellavely | 5 | 2 |
| Ambul | Rajangane | 5 | 2 |
| | Kopai | 5 | 2 |
| Guava | Ipalogama | 5 | 2 |
| | Dambulla | 5 | 2 |
| Pomegranate | Maritime pattu | 5 | 2 |
| | Kaluwanchikudi | 5 | 2 |
| | Valaichchenai | 5 | 2 |
| Okra/Brinjal | System G | 5 | 2 |
| Potato/Onion | Jaffna | 5 | 2 |
| **Total** | | 55 | 22 |

NT – New Technology; ET- Existing Technology

However, due to status in the field, it took a long time to interview and make observations with them. It took a long time to sort out the technological variegation adopted by the farmers. The incessant rains and flooding hampered mobility and accessibility to areas planned for the study. In addition, the country's presidential and general election process also restrained discussions with officers and farmers. Thus, the actual sample taken was as follows:

Table 2: The sample farmers taken:

| Crop | Location | Farmer | |
|---|---|---|---|
| | | NT | ET |
| Guava | Ipalogama | 5 | 2 |
| | Dambulla | 5 | 2 |
| Banana - Cavendish | Sevanagala | 5 | 2 |
| | Vellavely | 5 | 2 |
| Banana - Ambul | Rajangane | 5 | 2 |
| | Kopai | 5 | 2 |
| Pomegranate* | Maritime pattu | | |
| | Kalawanchikudy | | |
| | Valaichchenai | | |
| Okra/Brinjal* | System G | | |
| Potato/Onion* | Jaffna | | |
| **Total** | | 30 | 12 |

*Please see Item 7.5 for sample information of clusters of Pomegranate, Okra /Brinjal and Potato/Onion.

## 6.2 Data Analysis

Regarding data analysis, criteria relevant to finance and economics were calculated using an Excel package. Data relevant to values of parameters with new technology and existing technology were compared using tables.

## 6.3 Financial Gains to Farmers

Financial gains for farmers in adopting the new technology for the proposed crops were analysed by conducting a financial analysis for each crop separately. To achieve this the farm budget for each crop was prepared. Financial analysis was based on the market price of each crop in 2024.

## 6.4 Data Required for a Farm Budget

A farm budget includes costs required for the adoption of the new technology for crop production and benefits generated with the new technology.

Table 3: Data Requirement for farm budget comparison

| Item | With the adoption of new technology | Without new technology (existing technology) |
|---|---|---|
| **Cost** | Cost for land preparation,<br>Cost for planting material, | Cost for land preparation,<br>Cost for planting material, |

| | | |
|---|---|---|
| | Cost for irrigation,<br>Cost of applying fertilizer,<br>Cost for pest control,<br>Cost for disease control, Labour cost,<br>Cost of harvesting,<br>Cost of processing,<br>Any storage loss,<br>Any handling loss,<br>Cost of marketing,<br>Market prices or import parity prices | Cost for irrigation,<br>Cost of applying fertilizer,<br>Cost for pest control,<br>Cost for disease control, Labour cost,<br>Cost of harvesting,<br>Cost of processing,<br>Any storage loss,<br>Any handling loss,<br>Cost of marketing<br>Market prices or import parity prices |
| **Benefit** | Harvest quantity,<br>Quantity sold at the local market,<br>Quantity exported,<br>Local price, export parity price | Harvest quantity<br>Quantity sold at the local market,<br>Quantity exported,<br>Local price, export parity price |
| **Other expenses** | Taxes, interest payments of loans | Taxes, interest payments of loans |
| **Other gains** | Any subsidy | Any subsidy |

## 6.5 Criteria Used for the Financial Analysis

The criteria used in the financial analysis included the Average Net Income per farmer, the Payback Period, Financial Benefit Cost Ratio, Financial Net Present Value (FNPV), and Financial Internal Rate of Return (IRR).

## 6.6 Economic Gains to the Country

Economic gains to the country by adopting new technology were analysed by conducting an economic analysis for each of the crops selected. The economic analysis was based on financial analysis and financial values were converted to economic values using economic prices or shadow prices. Here, market prices were converted to economic prices using relevant conversion factors (which were used in the World Bank report for Sri Lanka or other reasonable conversion factors available). Further, transfer payments such as taxes and subsidies were not considered.

## 6.7 Criteria Used for Economic Analysis

The criteria used in economic analysis included Economic Benefit Cost Ratio, Economic Net Present Value (ENPV) and Economic Internal Rate of Return (EIRR).

# 7. Results and Discussion

## 7.1 Superiority of the New Technology Packages over the Existing Technologies

As proposed by the ASMP project office, this assignment was initially focused on Banana (Ambul and Cavendish), Guava, Pomegranate, Okra, Brinjal, Red Onion and Potato to assess the technical superiority of the new technology packages introduced by the ISP.

The technical superiority of the new technology packages was assessed relative to the existing technologies used by farmers. Technical superiority was explained by considering the contribution of a particular technology to enhance the benefits of a crop. The benefit of a crop depends on the performance of crop production. The performance of crop production can be measured by considering changes in relevant parameters due to the adoption of a new technology.

The introduction of new technologies by the ASMP is a necessity in Sri Lanka due to two main reasons. One of the reasons is the need for improved quality of produce to improve the accessibility to the export market. Other is to improve the regular availability of the produce with higher quality.

One of the important aspects of fresh fruits is the variation of the size and the appearance of the fruits. In the supermarket, consumers tend to pick the more appealing fruits from the display. Once sorted for size, the consumer should be able to buy the products without picking them. The appearance of Ambul banana with dark spots due to freckle disease on fruits should be avoided at the field along with any blemishes created by physical contact on to the bunch. Similarly, banana towards the end of the bunch are usually small in size and should be removed in the field. The technology packages introduced are comprehensive, and they are available as Operational Manuals for the set of crops handled by the ASMP.

The other important aspect is the expansion of the export market. The demand for phytosanitary standards is usually high in the export market. However, the ASMP strive to improve the quality of products both in the local and export markets equally. The Operational Manuals have been prepared to support the maintenance of phytosanitary standards of the export market.

The technology package and the 'Operational Manuals for various crops' have been introduced by the ISP. In addition, the Cluster Development Programme (CDP) of the SMP uses Q***uality enhancing technologies*** and ***Improved technology packages***. The former technology package is related to product quality enhancement, and the latter is related to agronomic and cultural practices. The Operational Manuals for Crops cover a comprehensive and outstanding report including the processing steps and preparing the products for export market.

## 7.2 Guava Production

### 7.2.1 Technical Superiority of New Agronomic Practices Introduced by ASMP over Existing Technology

1. Land preparation

   Field preparation consists of land tillage, composting, levelling, providing adequate drainage canals, and preparing planting holes.
   The ASMP has introduced a specific procedure for land preparation: land tillage, composting, and levelling. The initial land preparation is implemented with the Mould Board Plough (MBP) /Disc Plough using a 60 cm diameter disk plough. Deep ploughing is done in one direction and the next run is done perpendicular to the first direction after adding the Compost @ 5t/ac. However, most tractor operators do not have MBPs and use only the disc plough and disc harrows. Therefore, the initial tillage is done with the Disc Plough. The purpose of such a procedure is to achieve a uniform planting media with adequate organic manure and also to achieve a uniform depth of soil, facilitating easy drainage and outflow.

   The next step would be to break the clods into a finer structure and level the field with the disc harrow running in one direction and another running perpendicular to it with disks having a diameter of 40 cm. This will enable the field to reach the finer tilth that will be suitable for planting. About

100% of the farmers have adopted the procedure and are content with it.

2. Drainage improvement
It is recommended to provide an adequate canal system to provide for in-field and out-of-field drainage, depending on the slope of the land and the texture of the soil. 100% of the farmers have adopted the procedure and are happy with the impact of the better drainage of the fields.

3. Preparation of planting holes
Holes will be prepared only for the size of the potting bag as the soil is loosened and composted to accept the seedling as it is.

Observations:
1) The recommended steps of new technology are not adopted in the existing technology of guava cultivation. The general practice of field preparation for new guava planting in existing technology is to clear the lands of weeds and trees and dig planting holes of $1m^3$ at the specified spacing. The soil dug out from the hole is mixed with compost and laid back, after which the plant is planted at an elevated level. The rest of the land is left fallowed and periodically weeded. In this manner, compost will be required only for the volume of the planting hole but not the rest of the area.
2) As applied in new technology, it is a waste of compost when applied to the rest of the area which will provide nutrients for weed growth unless covered with black plastic mulch. Therefore, intercrop is compulsory in the new technology to use the compost applied to the entire field, along with the plastic mulch that will reduce weed growth and conserve soil moisture.
3) It is reported that around Rs. 64,000 is spent for field preparation of Guava in new technology on ½ ac, while in the existing technology, the cost for digging holes for 40-50 planting holes of the same extent and filling with soil after mixing with compost may cost around Rs. 15,000.
4) Despite the cost difference between the new and existing technology, the lack of such standard practices in existing technology as against new technology may affect the plant growth and production cycle and the final yield.

4. Planting
In the new technology, planting is done in a hole of the identical size of the plant bag, which is not different to existing technology.
a. Box system
The box system is the high density double row (HDDR) planting system with 1 m between rows and 1.5 m within the row, separated by a 4m gap between the next double row. Around 600 plants can be accommodated within 0.5 ac with this spacing but practically 550 plants are recommended within ½ ac. Seedlings are planted in adjoining rows so that they form a triangle between one plant in one row and 2 plants in the adjoining row. This facilitates minimising overlapping of branches of adjoining plants.

b. Espalier trellis system
The Espalier Trellis system also uses the HDDR system with 1.5 m between rows and 1.5 m within the row, separated by a 4 m gap between double rows. Theoretically, this spacing arrangement will occupy around 484 plants per 0.5 but 550 seedlings are recommended. The espalier trellis system consists of iron pipes and metal wires that assist the pruning and running of the branches along the wires as recommended. The espalier system allows the farmer to walk along the guava plant much closer and conduct the pruning and other practices accurately, which is deemed to give higher yields. With the Espalier system, the plants are trained to grow

and occupy the vertical space and allow to utilize more sunlight for the entire plant compared to the box system, where in the latter system the internal parts of the plant are shaded and inaccessible. The introduction of the espalier trellis system by the ASMP for fruit production is an important change in fruit crop planting methods in Sri Lankan agriculture. Espalier is a very practical technique that allows farmers and gardeners to grow fruit trees, shrubs and other branching and climbing plants in a two-dimensional manner, saving space while increasing productivity, facilitating caring for the plants, and maintaining aesthetics.

The Espalier system is reported to cost around Rs. 1.6 million for ½ ac, which would be exorbitant for an average farmer but yet some farmers appreciate it as giving higher yields than the box system and even opted to expand it with their own expenditure.

In the existing technology, the planting of guava is similar to the box system but at wider spacing of around 5m x 5m which will accommodate around 80 plants per 0.5 ac. This wider spacing induces the plant to grow taller and wider. This makes more branches but reduces the effective flowering points since much of the branches are shaded and retained within and under the canopy.

1. **Introduction to Espalier Trellis system**
    - Espalier involves training fruit trees (or shrubs and climbing plants) to grow flat against supports, such as fences or walls, almost two-dimensionally rather than in their natural growth pattern.
    - The word “espalier” originates from the Italian spalliera, meaning “something to rest the shoulder against.”
    - Initially developed by orchardists to maximize fruit production in limited spaces, espalier trees can also be found in historical gardens across Europe.
2. **Benefits of Espalier:**
    - Space-saving: Espalier allows you to grow fruit trees along fences or walls, saving valuable garden space. o Aesthetics: Espalier trees have an artistic or architectural quality that adds sophistication to any garden. o Abundance of Fruits: Even in small gardens, you can achieve a bountiful harvest using this technique.
    - Facilitate Caring for the Trellised Plants and Trees: Practices such as pruning, harvesting, spraying, and gagging can be applied very easily.
3. **Suitable Plants for Espalier:**
    - Choose flexible trees or shrubs with spurs for espalier trellising.
    - Apples, pears and other flexible branching fruit trees and shrubs are popular choices because they respond well to training and produce masses of fruits in a small space.
    - Pomegranate trees adapt very well to the Espalier Trellis system because they have flexible branches and produce spurs along those branches.
4. **How to train fruit trees with Espalier method:**
    - Start when the trees are young saplings (usually about a year to two years old).
    - Bend supple new-growth branches to shape and secure them to a trellis or wires.
    - Prune off new shoots that won’t conform to the desired pattern.
    - There are various patterns and forms for espalier, both formal and informal.

By mastering this art, farmers and gardeners can enjoy a fruitful harvest while adding visual appeal to the field or garden. One must remember that Espalier trellising is not only practical but also adds an elegant touch to the field or garden.

5. **References:**


- Moulton, M. (2024). How to Espalier Fruit Trees and Climbing Plants in 6 Easy Steps. Epic Gardening
- How to Prune and Train Espalier Fruit Trees. Nature Hills. (2019)
- An Easy Approach to Espalier. Fine Gardening
- Espalier Fruit Trees: Big Harvests in Small Spaces. Epic Gardening. (2023)
- How to Espalier Fruit Trees to Maximize Growing Space. Morning Chores


5. Irrigation

In new technology, micro irrigation, preferably micro sprinklers, must be used for irrigation, irrespective of the intercrop. The irrigation rate is decided according to the daily evaporation (evapotranspiration) applied in 3 cycles per week. An agro well and a water pump are essential components of the irrigation system. However, only 3 out of 5 farmers are practicing micro irrigation, whereas the other 2 are irrigating with gravity flow from the Mahaweli Canal system. Irrigation with gravity floor is practised purely due to economic reasons because they have free-flowing water. However, they have agro wells and would pump with the hose at a time of water scarcity.

In the existing technology, irrigation is performed by pumping from the agro well and applying through the hose with almost flood irrigation of the field. The amount of water is not quantified, and there is no technical basis for the amount or time of application. This irrigation practice will tend to wet the soil profile to saturation, which is a wasteful practice.

6. Fertilization / Fertigation
   In new technology, fertilizer application is expected to be undertaken through the fertigation unit but the farmers tend to apply fertilizer manually. However, they apply in the required quantity in the recommended time.

   In the existing technology, they always apply fertilizer manually, while the quantity per application and time of application vary and are different to the new recommendation. This shows that even though the recommendation in new technology is to use the fertigation unit, farmers are not willing to depend on that but to manually apply fertilizers.

7. Weed control
   With the new technology, the intercrop of chilli and long bean along with the plastic mulch have completely controlled the weed growth. This affected almost zero cost of weed control. 100% of the farmers are happy about the fewer problems with weeds.

   In the existing technology, intercrop is not a part of farming and therefore the farmer has to bear the cost of weed control manually at least once a month. However, with the progress of guava growth farmers tend to neglect intercropping.

8. Pruning
   The pruning method of the box system is to train the tree to a wider box shape with selective pruning of excess branches and shoots. In the espalier system, pruning is conducted to train the plant to run on a horizontal plane with only 3 tiers of upward growth. This would give more flowering points and better sunshine allowed. The overall effect would give a higher yield in the espalier system as against the box system. 100% of the farmers adopting new technology have approved the new pruning technology as beneficial to them.

   In the existing technology, there is no such regular and scientific pruning method adopted resulting in haphazard growth of branches. This results in energy spent on the unnecessary growth of branches reducing the yield.

9. De-blossoming
   The farmers have not reported practising de-blossoming to improve the yield.

10. Intercropping
    All farmers have reported the benefits of intercropping in the new technology such as control of weeds and additional income from them during the initial 3 years.

    These benefits are not realized in existing technology since intercropping is not a part of guava cultivation.

11. Pest and disease control
    In the new technology, control of pests and diseases is addressed through Integrated Pest Management approaches. Especially the farmers have been trained to identify pests and diseases at the very early stages and take the necessary steps to control them. Also, they are trained to handle the bagging process which will effectively control the pest damage.

    In the existing technology, the bagging process is absent, but the pheromone trap for fruit flies is the most common pest control approach. Therefore, the fruits in existing technology are more prone to pests and diseases, resulting in yield losses.

12. Flower induction
    Farmers adopting new technologies have not reported the use of flower induction although it is an approach to produce fruits for markets in future. This is not practised with existing technology by the farmers.

    There are mainly three ways to induce flowering, chemical and physiological stress:
    - Apply an Ethrel-Urea 1:1 mix on the foliage of the tree.
    - Pinch the terminal buds or branches of mature guava trees. This method produces a quick flowering response and is used as a regular practice by farmers.
    - Induced physiological stress:
      Deprive the trees of nutrients and/or water.

13. Bagging
    In the new technology, bagging is necessarily adopted for the conservation of fruits and preventing them from pest damage. Differently coloured bags are used to indicate the stage and age of the fruits. 100% of the farmers are engaged in inserting the fruits in the bags at a very young and tender age, showing that they are careful and concerned about the preservation of the quality of the fruit.

    In the existing technology, inserting fruits into the bags was not performed earlier, but later understanding the damages by the fruit fly, the farmers started to insert the fruits in paper bags. However, at present some farmers are reported to be using the proper bag for this purpose.

14. Management of fruit inventory
    Tree identification and nomenclature (blocking and tagging) is important in identifying the origin of fruit when it goes for export purposes. In the new technology, this aspect is emphasized as compulsory. However, since guavas are not yet produced for export purposes, this is yet to be undertaken.

    This concept is not taken in existing technology.

15. Harvesting
    6-8 weeks after bagging
    In the new technology, once the bag is inserted, the fruit is taken out only to change the bag to indicate the age of the fruit. Otherwise, the same bag will be kept until the fruit has reached the suitable age to harvest, around 6-8 weeks. While this range of weeks is long, it is the skill of the farmer that will indicate which week is suitable for harvesting.

In the existing technology, only if the bags are inserted, the farmer will have to choose when to open, but otherwise, the fruit is exposed to nature and the colour and feeling will enable the farmer to decide when to harvest.

Use of shears or sharp cutting tools
In the new technology, the fruit is harvested by using a scissor or a sharp tool which will not damage the petiole. This is extremely important as the wound on the surface will tend to infections by microorganisms.

However, in the existing technology, such a recommendation is not available but the farmers would pull the fruit with the stalk, sometimes damaging the location where it is stuck onto the branch. This may at times allow micro-organisms to infect the wound.

### 7.2.2 Response of the Farmers from the Ipalogama Guava Cluster for the Adoption of the New Technology

The ASMP advised Ipalogama cluster farmers to cultivate a one-acre guava field and they were provided with some materials relevant to the introduced new technology, free.

Table 4 indicates the practices of the new technology package the ASMP introduced for the guava fruit crop and the percentages of the interviewed farmers adopting these practices. As per the Table, some of the introduced practices have been adopted.

The first four practices of Table 4 are related to the planting material of guava. Of the given two varieties, the White guava variety is popular and all the interviewed farmers (100%) have grown White guava. The project has provided selected farmers with free seedlings of White variety. Some of the interviewed farmers had been growing White guava before being selected for the guava cluster. Mostly, farmers grow guava using air layering plants but they have used seedlings under the ASMP guidance. According to the farmers, air-layering plants start flowering 03 months after planting, earlier than initiation of flowering in seedling plants.

Table 5 presents land preparation practices of the new technology package introduced by the ASMP. As shown in Table 5, deep ploughing is practised twice using disc plough, adding compost, harrowing and micro levelling. All the interviewed farmers (100%) adopted 1$^{st}$ deep ploughing and micro levelling with a backhoe. Out of the interviewed farmers, 60% adopted the whole package while 40% of the farmers did not adopt all practices of the soil preparation package.

A mini sprinkler irrigation system has been provided free to the farmers of the guava clusters. In addition, groups of four farmers are provided an electric pump and a solar panel free, to generate electricity for operating an electric pump. However, during the survey, the Ipalogama guava cluster had not received the solar panel. Four farmers share an electric pump to irrigate Guava fields from agro wells or the Mahaweli canal.

A fertigation technique has been introduced to apply both liquid organic fertilizer and chemical fertilizer. Out of the interviewed farmers, 60% have used this practice. Except for one farmer, the other two farmers had been practising fertigation for 7 months. According to the farmers, dissolved fertilizer blocks the sprinklers and they had to replace sprinklers. Further, some farmers think that fertilizer cannot be applied sufficiently through fertigation techniques. Farmers who have practised fertigation have used an anti-clogging flushing compound, Phosphoric Acid, to clear sprinklers.

All the interviewed farmers (100%) have practised double-row planting and they appreciated this practice because farmers could increase their harvest and income. With this practice, plant density has increased and there is a considerable land space between two guava beds. Farmers have once grown other crops such as chilli and long beans when guava plants were growing. When guava plants have grown, farmers cannot easily move within guava beds to do other cultural practices such as pruning and applying pesticides. Therefore, farmers have not grown continuously other crops on this alley and it is used to move for implementing cultural practices. Some farmers interviewed have earned a considerable income growing chilli on these alleys only during one season and according to farmers, they were able to recover the cost spent on guava cultivation.

All the interviewed farmers have been pruning guava plants properly. By pruning guava plants, farmers can increase harvesting frequency and the volume of harvest. Before introducing the espalier trellis system farmers were practicing box pruning. According to the farmers, espalier trellis pruning causes to increase yield of a plant compared to box pruning. It was observed that the espalier trellis pruning prevents mutual shading and the box pruning system cannot prevent mutual shading. Therefore, the bearing is higher in the espalier pruning system compared to the box pruning system. The ASMP has provided each cluster farmer with the material required for constructing an espalier for a half-acre or a quarter-acre, free. After experiencing its benefits, farmers revealed that they would construct espalier for the rest of the guava cultivation themselves.

De-blossoming is practised by all the interviewed farmers for four months after commencement of flowering three months after planting, i.e. until the seventh month after planting. Thereafter, farmers let flowers bear fruits.

Bagging fruits is another practice the ASMP introduced. Initially, the ASMP provided bags. All farmers practice bagging fruits as it protects fruits from physical damage and pest attacks. Further, bagging improves the quality of fruits which can be sold at a higher price.

Table 4: Practices of new technology introduced by the ASMP for guava and the percentage of farmers from the Ipalogama guava cluster adopting these practices

| Introduced Practices | % of the Interviewed Farmers Adopted | Remarks |
|---|---|---|
| White varieties to renovate the existing field of genetic material | 100% (5) | Out of these two varieties, the white variety is popular |
| Red variety for fresh and processing to expand market access for farmers | 0 | |
| Rooting of terminal branches | 0 | The project has provided seedlings |
| Air layering | 0 | |
| Mini-sprinkler irrigation systems | 100% (5) | ASMP provided free |
| Precision fertigation with a fertilizer mixture | 60% (3) | 40% of the interviewed farmers practised fertigation for 7 months after planting and 20% of the farmers continued. Dissolved |

| | | |
|---|---|---|
| | | fertilizer blocks the sprinklers. |
| Anti-clogging flushing components | 60% (3) | When practising fertigation, they have used. |
| Macro level study of the drainage pattern of the guava area to identify poorly drained farms affected by Fusarium Wilt and to determine the slope patterns to quickly evacuate water using on-farm micro drainage technology | 0 | Not reported |
| Hexagon and equilateral triangle patterns | 0 | |
| Double row planting pattern suitable for multiple cropping | 100% (5) | Farmers appreciate this practice |
| Formulation of fertilizer regimes based on complete soil tests and foliar analysis | 0 | Not reported |
| Pest population and pest damage surveys to assess pest threshold status for application of pesticides. | 0 | Not reported |
| Mitigation of guava dieback disease using disease-specific fungicide mixes | 0 | Not reported |
| Control of anthracnosis and other pre- and post-harvest Diseases | 0 | Not reported |
| At about 0.7 m high the central leader trunk is cut off to encourage the lateral growth of branches. 3 – 4 lateral branches are left to grow to about 20 cm and tier of lateral branches. Selective short pruning of branches to encourage growth of lateral branches. | 100% (5) | All farmers practice |
| Pruning mature trees bearing fruits | 100% (5) | All farmers practice |
| Espalier Trellis System | 100% (5) | Compared to box pruning espalier technique produces more fruits and farmers tend to practice this. |
| De-blossoming | 100% (5) | De-blossoming is practised from the 3rd month to the 7th month after planting. |
| Introduction of bagging | 100% (5) | All farmers practice bagging fruits |

Table 5: Land preparation practices of new technology introduced by the ASMP for guava and the percentage of farmers from the Ipalogama guava cluster adopting these practices

| Introduced Land Preparation Practices | Number of Farmers Implemented | Remarks |
|---|---|---|
| Deep ploughing using mouldboard plough | 100% (5) | The 1st ploughing was practised using a disc plough provided by the ASMP |
| Application of compost | 80% (4) | |
| Deep ploughing again using mouldboard plough (perpendicular to first ploughing) | 80% (4) | The 2nd ploughing was also made using a disc plough provided by the ASMP |
| Disking or harrowing (two perpendicular passes) | 60% (3) | A rotary tiller was used for this operation |
| Micro levelling to facilitate drainage works | 100% (5) | Levelling and making ditches to improve drainage facility made by the ASMP using a backhoe machine |

### 7.2.3 Practices of the Existing Technology of Guava Cultivation

Guava is cultivated at the commercial level in the dry zone of Sri Lanka around the Dambulla area. Farmers who grow guava adopting conventional practices are called existing guava farmers and the technology is named existing guava technology.

Both the guava cluster farmers and the existing farmers prepare land almost similarly. Two times disc ploughing, levelling with a rotary and making drains with a backhoe. However, the practices adopted by the existing guava farmers corresponding to the practices given in Tables 4 and 5 are considered when checking the superiority of the new technology.

The existing farmers also grow white guava, called apple guava at the commercial level. Existing farmers used to grow guava from air layering plants. Usually, they practice flood irrigation without considering the irrigation requirement of the crop and excessively pump water to the field.

Fertilizer is manually applied and excess quantities of fertilizer are usually applied. Existing farmers adopt single-row planting patterns and therefore, the number of plants required for an acre is 600 which is lower than that of the double-row planting system.

Existing farmers follow the box pruning method and they do not practice de-blossoming. Existing farmers adopt bagging for protection from insect attacks but do not use different colour bags to for harvesting management.

### 7.2.4 Superiority of the New Technology Compared to the Existing Technology

The superiority of the new technology is assessed against the existing technology by comparing the efficiency of guava production using each technology. Efficiency is the technical efficiency that is explained as the quantity of output per quantity of input. Concerning guava production, if the new technology can reduce the quantity of inputs required to produce a given quantity of guava production per unit area (per acre or hectare) per year or the new technology can increase guava production per unit area for a given quantity of input per year, the efficiency of the new technology is higher than existing technology of guava production. Then, it can be said that the new technology is superior to the existing technology. Further, efficiency can be measured using cost-benefit analysis. If the new technology can generate IRR and NPV greater than those of the existing technology, the new technology is superior to the existing technology.

### 7.2.5 Utilization of Input

Table 6 shows the average amount of some of the inputs currently utilized for growing guava per acre per year using the new technology and existing technology. The amounts of all input items utilized for cultivating guava with the new technology are lower than those utilized for cultivating guava with the existing technology.

The new technology can reduce the average quantity of water utilised annually to irrigate guava cultivation to 724,992 litter from 1,152,000 per acre used in existing technology. With the new technological package, mini weather stations have been established to update cluster farmers about daily irrigation requirements, irrigation intervals, and irrigation periods by SMS. It is a convenience for them to apply irrigation as recommended and prevent over-irrigation. However, some of the beneficiary farmers believe that this informed irrigation requirement is not sufficient for crop growth and they use more water.

The average annual labour used for irrigating an acre of guava cultivation decreases from 60 to 22.3 man-days with the adoption of the new technology. A mini sprinkler system is a component of the new improved technology package. As a sprinkler system has been installed in a guava field, the only operation a farmer has to do is keep the pump operating for a required time. Further, farmers who irrigate with a mini sprinkler system can be involved in other works such as weeding, pruning etc., while irrigating.

When doing flood irrigation under existing technology, a farmer diverts water from one plot to another by blocking and unblocking drains in the field. Therefore, farmers who adopt existing technology happen to spend more time in the field when irrigating compared to those who adopt the new technology. It seems that farmers adopting the new technology do not spend time only on irrigating. As a consequence of a reduction in man-days required for irrigation, the cost of labour required for irrigation has also reduced from Rs. 150,000/= to Rs. 55,750/= per acre per year.

The new improved technology package has caused a reduction in the cost of energy annually used for irrigation from Rs. 80,000/= to Rs. 42,237/= per acre. This reduction in the cost of energy is mainly due to a reduction in the amount of irrigation or a reduction in the time of irrigation. Farmers can get this energy bill reduced to zero by using electricity from solar panels provided by the ASMP. When conducting the survey, some farmers have received solar panels but not operating (now solar panels are operating) and therefore, the cost of energy for irrigation is accounted for.

As depicted by Table 6, farmers could reduce the quantity of fertilizer used from 1200 kg to 371 kg per acre per year by adopting the new technology. Corresponding to the reduction in fertilizer, the cost of fertilizer also decreases from Rs. 216,000/= to Rs. 145,590/= per acre per year. The labour requirement for applying fertilizer decreases from 24 man-days to 22.5 man-days per acre per year with the adoption of the new improved technology. The cost of labour for applying fertilizer also decreases from Rs. 60,000/= per acre per year as labour requirement decreases. The new improved technology introduced fertigation to farmers. When practising fertigation, farmers happen to reduce the quantity of fertilizer.

Most of the interviewed farmers have practised fertigation during the first 7 months and thereafter, applied manually. However, farmers accept that they apply fertilizer more than enough and they sometimes tend to manually apply fertilizer while fertigating too. Precision fertilizer application, which is said to be fertilizer applied based on soil analysis and foliar analysis, has not been practised. However, it seems that with the new improved technology, some of the interviewed farmers have tended to practice fertigation and consequently reduce the quantity of fertilizer applied.

Table 6: Average amount of some inputs required for growing guava per acre per year

| Item | Unit | New Technology | Existing Technology |
|---|---|---|---|
| Average quantity of water annually irrigated per acre | Littre | 724,992.00 | 1,152,000.00 |
| Average annual labour utilization for irrigation per acre | Man day | 22.30 | 60.00 |
| Average annual energy cost for irrigation per acre | Rs. | 42,236.80 | 80,000.00 |
| Average annual labour cost for irrigation per acre | Rs. | 55,750.00 | 180,000.00 |
| Average quantity of fertilizer annually applied per acre | Kg | 370.80 | 1,200.00 |
| Average amount of labour utilized to apply fertilizer per acre | Man day | 22.56 | 24.00 |
| Average annual fertilizer cost per acre | Rs. | 145,590.00 | 216,000.00 |
| Average annual labour cost for applying fertilizer per acre | Rs. | 56,250.00 | 90,000.00 |

### 7.2.6 Guava Production with the New Technology and the Existing Technology

Although guava takes three months after planting to flower, the fruit set is allowed seven months after planting. After fruit setting, guava takes four months to be mature enough for harvesting. Therefore, guava can be harvested from the second year after planting. Table 7 presents changes in average production and average revenue of guava per acre per year over five years with the new improved technology and existing technology. The effects of all practices of both the new improved and existing technologies can be observed in fruit production. Therefore, guava production corresponding to these two technology packages can be taken as an indicator to evaluate the superiority of the technology.

According to Table 7, the average annual production of guava per acre with the practices of the improved new technology is higher than that with the existing technological practices over the five years. One of the practices which is directly linked with production increase is the double row planting pattern of the new improved technology, which increases guava plant density. Plant density with the new improved technology is 1100 plants per acre compared with 600 plants per acre with the existing technology.

The difference in pruning practice is another important practice causing an increase in guava production. Espalier trellis system and box pruning technique are practised in the new improved technology package and box pruning technique is practiced by existing farmers. As farmers reported, the espalier trellis technique produces more fruits in a guava plant than the box pruning technique does. The espalier trellis system prevents mutual shading compared to the box pruning technique and the fruit-bearing of a guava bush pruned with the box pruning technique shows a decreasing gradient from top to bottom. In addition, pruning properly practised can increase the yield of a guava bush by increasing the number of fruit-bearing shoots. It seems that when a guava bush becomes old, its production increases with regard to both technological packages because a guava bush increases its branches with age. Average annual guava production with the new improved technology package increases from 2,060 kg per acre in the first year to 36,400 kg per acre in the fifth year while that with the existing technology increases from 500 kg per acre in the first year to 14,000 kg per acre at fifth year (Table 7). Guava production with the new improved technology is greater than that with the existing technology over the years of the considered period (Box - 01).

**Box - 01**
**Yield Forecasting of Guava**

Farmers of the Ipalogama guava cluster have been reaping guava harvest for two years with the new improved technology. These farmers have been cultivating guava for many years too with the existing technology.

However, this study is conducted for five years and guava yield with the new improved technology for three years ahead is forecast. Here, information on the average number of guava fruits harvested from a bush per time in 1$^{st}$, 2$^{nd}$, 3$^{rd}$, 4$^{th}$, 5$^{th}$ and 6$^{th}$ years is collected. Then, information on the average number of harvesting times in each year is collected.

Farmers can predict the number of guava fruits with their experience and fruits per kilo are accounted. Usually, three grade 1 guava fruits are required for a kilo.

When selling guava, the buyer categorizes guava production based on size, appearance and damages into two grades. Grade 1 guava is bought at a higher price. As the interviewed farmers report, about 86% of total production is grade 1 and about 14% of the total production is grade 2 with regard to the new improved technological package while 98% of total production is grade 1 and 02% of the total production is grade 2 with the existing technology.

The value of guava varies according to grade and the price also varies. The price considered is Rs. 400/= per kilo for grade 1 and Rs. 100/= per kilo for grade 2. Farmer revenue has been calculated over these five years considering these market prices. Farmers have been able to increase their average annual revenue by adopting the new improved technology relative to those who are adopting the existing technology. As the interviewed farmers reported, their gross annual revenue varies from Rs. 0.74 million per acre in the first year to Rs. 13.02 million per acre in the fifth year with the new improved technology. Average gross annual revenue varies from Rs. 0.198 million per acre to Rs. 5.544 million per acre over the corresponding years with the existing technology. It seems that farmers could increase their average annual income by adopting the new improved technology compared to those who are adopting the existing technology.

Table 7: Changes in average production and average revenue of guava per acre per year over five years with the new improved technology and existing technology

| Description | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | New improved technology | | | | | Existing technology | | | | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Average production of guava per acre per year (kg) | 2,060 | 9,600 | 22,660 | 30,000 | 36,400 | 500 | 2,400 | 4,000 | 7,200 | 14,000 |
| Average quantity of grade 1 guava production per acre per year (kg) | 1,774 | 8,280 | 19,568 | 25,800 | 31,280 | 490 | 2,352 | 3,920 | 7,056 | 13,720 |
| Average quantity of grade 2 guava production per acre per year (kg) | 286 | 1,320 | 3,092 | 4,200 | 5,120 | 10 | 48 | 80 | 144 | 280 |
| Average value of the quantity of grade 1 guava production per acre per year (Rs. million) | 0.71 | 3.31 | 7.83 | 10.32 | 12.51 | 0.196 | 0.9408 | 1.568 | 2.8224 | 5.488 |
| Average value of the quantity of grade 2 guava production per acre per year (Rs. million) | 0.03 | 0.13 | 0.31 | 0.42 | 0.51 | 0.002 | 0.010 | 0.016 | 0.0288 | 0.056 |
| Average gross revenue from guava per acre per year (Rs. million) | 0.74 | 3.44 | 8.14 | 10.74 | 13.02 | 0.198 | 0.9504 | 1.584 | 2.8512 | 5.544 |

### 7.2.7 Cost of Production of Guava

The cost of production of guava can also be used as an indicator to check the superiority of technology. Table 8 presents changes in the cost of production of guava based on the quality of products, the overall (total) production cost and grade 1 guava production cost over six years with the new improved technology while Table 9 presents changes in the cost of production of guava based on overall (total) production and grade 1 guava production over six years with the existing technology. Based on the cost of cultivation, the cost of production for the new improved technology and the existing technology is calculated. For each case, the cost of production for grade 1 guava production and total guava production is calculated. Grade 1 guava production is reported more than 85% of total production. As guava harvesting starts in the second year, the first-year cost (investment) is equally distributed over the next five-year period (from the second year to the sixth year).

The average costs of production for grade 1 guava and the total cost of production for guava production based on five years are Rs. 146/= per kilo and Rs. 126/= per kilo respectively with the new improved technology. However, the average costs of production for grade 1 guava and total guava production based on five years are Rs. 330/= per kilo and Rs. 323/= per kilo respectively with the existing technology. Compared to the current market price for grade 1 guava, Rs. 400/= per kilo, all cost of production figures are low. The current market price for grade 2 guava which is Rs. 100/= per kilo is lower than the above cost of production figures.

As shown in Table 8 and Table 9, the cost of production for total production and grade 1 guava production with the new improved technology has decreased over the years. Cost of production of total production for year 2, year 3, year 4, year 5 and year 6 are Rs. 666/= per kilo, Rs. 224/= per kilo, Rs. 118/= per kilo, Rs. 107/= per kilo and Rs. 90/= per kilo respectively with the new improved technology. With regard to grade 1 guava production, the cost of production for year 2, year 3, year 4, year 5 and year 6 are Rs. 773/= per kilo, Rs. 260/= per kilo, Rs. 137= per kilo, Rs. 124/= per kilo and Rs. 105/= per kilo respectively with the new improved technology (Table 8).

In the case of existing technology, the cost of production of total production for year 2, year 3, year 4, year 5 and year 6 are Rs. 3,347/= per kilo, Rs. 728/= per kilo, Rs. 462/= per kilo, Rs. 262/= per kilo and Rs. 138/= per kilo respectively. With regard to grade 1 guava production, the cost of production for year 2, year 3, year 4, year 5 and year 6 are Rs. 3,415/= per kilo, Rs. 743/= per kilo, Rs. 471= per kilo, Rs. 267/= per kilo and Rs. 140/= per kilo respectively (Table 9).

According to the information given in Table 8 and Table 9, the cost incurred in producing a kilo of guava is reduced with the new improved technology compared to the existing technology. Further, the time required for covering the cost of production or breakeven point is reduced with the new improved technology to the third year from the fifth year with existing technology.

Table 8: Changes in the cost of production of guava based on total production and grade 1 guava production over six years with the new improved technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Cost of cultivation (Rs/acre) | 2,060,970 | 959,016 | 1,740,576 | 2,261,976 | 2,797,976 | 2,867,576 |
| Total production (kg) | | 2,060 | 9,600 | 22,660 | 30,000 | 36,400 |
| Grade 1 production (kg) | | 1,774 | 8,280 | 19,568 | 25,800 | 31,280 |
| Cost of production of total production (Rs/kg) | | 666 | 224 | 118 | 107 | 90 |
| Cost of production of grade 1 (Rs/kg) | | 773 | 260 | 137 | 124 | 105 |

Table 9: Changes in the cost of production of guava based on total production and grade 1 guava production over six years with the existing technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Cost of cultivation (Rs/acre) | 1,045,180 | 1,464,400 | 1,539,200 | 1,637,200 | 1,676,000 | 1,717,200 |
| Total production (kg) | | 500 | 2,400 | 4,000 | 7,200 | 14,000 |
| Grade 1 production (kg) | | 490 | 2,352 | 3,920 | 7,056 | 13,720 |
| Cost of production of total production (Rs/kg) | | 3,347 | 728 | 462 | 262 | 138 |
| Cost of production of grade 1 (Rs/kg) | | 3,415 | 743 | 471 | 267 | 140 |

### 7.2.8 Financial Analysis

Financial analysis is conducted to check how the project is benefiting beneficiaries. The following conditions are considered in conducting the financial analysis.

1. The ASMP has provided free land preparation, a mini sprinkler system and an espalier system. These can be considered as subsidies to beneficiaries to motivate them. Generally, subsidies are considered as income in financial analysis. Here, the value of these items is considered a cost to the beneficiaries because the analysis is focused on checking the superiority of technologies and the cost incurred in adopting these technologies should be covered by the project.

2. All taxes such as VAT, PAL, SSL and duties of the imports are included in the market price of these commodities.

3. Inflation of input prices and output prices is not considered. It is assumed that the effect of inflation may be cancelled out

4. Both inputs and guava production are valued using existing market prices.

5. Guava production starts in the second year after planting and benefits start from the same year. The analysis is done for six years.

6. The discount rate used for calculating NPV, Present Values of cost and benefit is the average fixed deposit interest rate (8%).

Table 10 presents FIRR, FNPV and benefit-cost ratio relevant to an acre of guava cultivation with the new improved technology and the existing technology. According to Table 10, FIRR for an investment in guava cultivation with the new improved technology is 94% and that is 14% with the existing technology. These FIRR values indicate that an acre of guava cultivation with the new technology generates benefits at a higher rate (94%) to a beneficiary than that with the existing technology (14%). The present value (at 8%) of net worth generated by an acre of guava cultivation with the new improvement is Rs. 15.38 million per annum while the existing technology is Rs. 0.613 million per annum. The benefit-cost ratio regarding the new technology is 262% and that for the existing technology is 109%. According to these values criteria, guava farmers can increase their benefits by adopting the new improved technology compared to the existing technology.

Table 10: IRR, NPV and B/C for NT and ET

| Criterion | NT | ET |
|---|---|---|
| FIRR | 94% | 14% |
| FNPV (Rs. million) - at bank fixed deposit rate, 8% | 15.38 | 0.613 |
| B/C | 262% | 109% |

### 7.2.9 Economic Analysis

Based on the financial budget, an economic analysis is conducted. Here, economic values for market prices are calculated using relevant conversion factors and transfer payments for import commodities such as fertilizer, insecticides, fungicides and weedicides are removed to get economic values.

Table 11 presents EIRR, ENPV and benefit-cost ratio relevant to an acre of guava cultivation with the new improved technology and the existing technology. According to Table 11, EIRR for an investment in guava cultivation with the new improved technology is 93% and that is 15% with the existing technology. These EIRR values indicate that an acre of guava cultivation with the new technology generates benefits at a higher rate (93%) to the whole economy than that with the existing technology (15%). The present value (at 8%) of net worth generated by an acre of guava cultivation with the new improved technology is Rs. 11.13 million per annum to the whole economy while that with the existing technology is Rs. 1.49 million per annum. The benefit-cost ratio regarding the new technology is 263% and that for the existing technology is 110%. According to these values criteria, guava cultivation by adopting the new improved technology can increase the benefits and GDP of the country compared to that with the existing technology.

Table 11: IRR, NPV and B/C for NT and ET

| Criterion | NT | ET |
|---|---|---|
| EIRR | 93% | 15% |
| ENPV (Rs. million) - at bank fixed deposit rate, 8% | 11.13 | 1.49 |
| B/C | 263% | 110% |

### 7.2.10 Issues Related to Guava Cultivation

With regard to guava cultivation, the interviewed farmers are not faced with any serious issues of guava marketing, irrigation, fertilizer availability, planting material availability, agrochemical availability and machinery availability. However, 20% of the interviewed farmers mentioned that there is a risk to life when applying pesticides to grown guava bushes. Grown guava is higher than farmers' accessibility and vaporized insecticides have to be inhaled. Therefore, drone technology can be used to apply insecticides to reduce health issues.

At present, there is no marketing issue as guava production is reduced due to anthracnose disease which affects most guava cultivation. Therefore, currently, there is demand for guava and better market prices. If guava production exceeds market demand, marketing issues might appear.

### 7.2.11 Conclusions and Recommendations

The study shows that guava cultivation can be more lucrative with the new improved technology compared to the existing technology. However, it seems that farmers who were selected for the guava clusters have not properly and continuously practised the introduced new technology package. For example, only 20% of the interviewed farmers continue fertigation which helps farmers to reduce fertilizer costs preventing waste of fertilizer and application cost.

Irrigation costs can be reduced and more water can be saved if all farmers can use solar panels.

Soil testing and foliar analyses are not practised. If farmers are provided the importance of following this information and accessibility to get these tests done, guava production can be made more cost-effective.

The new improved technology introduced by the ASMP can generate more benefits to individual farmers and the whole economy and consequently increase the GDP of the country compared to the existing technology.

Further, these benefits completely depend on the current market price derived from high local market demand. Several years ago, most of the guava cultivations were destroyed by a disease called phytophthora. Therefore, it is necessary to focus on the guava market before expanding guava cultivation.

Table 12: Cash flows of the financial analysis of an acre of guava cultivation with new improved technology

| **Year** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| Land preparation | 130,844 | | | | | |
| Planting material (seedlings) | 73,920 | | | | | |
| Labour cost for planting | 6,000 | | | | | |
| Mini sprinkler irrigation system per acre | 150,505 | | | | | |
| 2 hp electric pump | 22,000 | | | | | |
| Construction of espaliers | 1,062,500 | | | | | |
| Cost for irrigating guava | 97,987 | 97,987 | 97,987 | 97,987 | 97,987 | 97,987 |
| Cost for applying fertilizer | 118,980 | 198,668 | 251,768 | 251,768 | 251,768 | 251,768 |
| Cost for weed control | 254,800 | 254,800 | 254,800 | 254,800 | 254,800 | 254,800 |
| Insect control expenditure | 73,436 | 73,436 | 73,436 | 73,436 | 73,436 | 73,436 |
| Cost for managing fungal diseases (Rs) | 34,448 | 34,448 | 34,448 | 34,448 | 34,448 | 34,448 |
| Cost for pruning practices | 37,000 | 72,700 | 96,700 | 108,700 | 108,700 | 108,700 |
| Cost for bagging fruits. | | 70,400 | 820,000 | 1,162,000 | 2,728,000 | 1,680,000 |
| Cos for harvesting | | 10,660 | 44,400 | 183,600 | 200,800 | 212,800 |
| Depreciation of sprinkler system, pump and espalier at 10% | | 123,500 | 123,500 | 123,500 | 123,500 | 123,500 |
| **Cash outflow** | **2,062,420** | **936,599** | **1,673,539** | **2,166,739** | **3,749,939** | **2,713,939** |
| **Cash inflow (Revenue of guava)** | **-** | **738,200** | **3,444,000** | **8,136,400** | **10,740,000** | **13,024,000** |
| **Net cash flow** | **(2,062,420)** | **(198,399)** | **1,770,461** | **5,969,661** | **6,990,061** | **10,310,061** |

Table 13: Cash flows of the financial analysis of an acre of guava cultivation with the existing technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Land preparation | 63,000 | | | | | |
| Planting material (seedlings) | 105,000 | | | | | |
| Compost | 3,000 | | | | | |
| Labour cost for planting | 8,000 | | | | | |
| 2 hp electric pump | 22,000 | | | | | |
| Cost for irrigating guava | 230,000 | 230,000 | 230,000 | 230,000 | 230,000 | 230,000 |
| Cost for applying fertilizer | 118,980 | 306,000 | 306,000 | 306,000 | 306,000 | 306,000 |
| Cost for weed control | 270,000 | 270,000 | 270,000 | 270,000 | 270,000 | 270,000 |
| Insect control expenditure | 541,200 | 541,200 | 541,200 | 541,200 | 541,200 | 541,200 |
| Cost for pruning practices | | 16,000 | 72,000 | 144,000 | 168,000 | 168,000 |
| Cos for harvesting | | 4,000 | 8,400 | 16,000 | 28,800 | 48,000 |
| Depreciation of water pump at 10% | | 2,200 | 2,200 | 2,200 | 2,200 | 2,200 |
| **Cash outflow** | **1,361,180** | **1,369,400** | **1,427,600** | **1,507,200** | **1,544,000** | **1,563,200** |
| **Cash inflow (Revenue of guava)** | | **197,000** | **827,400** | **1,576,000** | **2,851,200** | **5,340,000** |
| **Net cash flow** | **(1,361,180)** | **(1,172,400)** | **(600,200)** | **68,800** | **1,307,200** | **3,776,800** |

Table 14: Conversion factors for guava production with the new improved technology

| Item | Type | Unit | Unit Price (LKR) | | 1) Eliminate transfer payments (VAT) | | 2) Elimination of duty and subsidies | | | CF | Final |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Financial | Economic | VAT (18%) | Excl. VAT | PAL =10% | SSL =2.5% | Final | | |
| Disc plough 1 for land preparation (Average CF) | Non tradable | acre | 25000 | 19625 | | | | | 25000 | 0.785 | 19625 |
| Disc plough 2 for land preparation (Average CF) | Non tradable | acre | 20000 | 15700 | | | | | 20000 | 0.785 | 15700 |
| Rotavator for land preparation (Average CF) | Non tradable | acre | 16667 | 13084 | | | | | 16667 | 0.785 | 13084 |
| Backhoe for land preparation (Average CF) | Non tradable | hr | 3107 | 2439 | | | | | 3107 | 0.785 | 2439 |
| Planting material (other agriculture) | Tradable | plant | 66 | 48 | | | | | 66 | 0.723 | 48 |
| Compost (other manufacture) | Tradable | kg | 20 | 16 | | | | | 20 | 0.791 | 16 |
| Cost for Mini sprinklers | Tradable | number | 213.6 | 166 | | | | | 214 | 0.776 | 166 |
| Pipe length | Tradable | m | 79 | 61 | | | | | 79 | 0.776 | 61 |
| Sprinkler instalment cost per acre | Non tradable | Lumpsum | 28400 | 20505 | | | | | 28400 | 0.722 | 20505 |
| Electric water pump (2 hp) | Tradable | Lumpsum | 22000 | 17072 | | | | | 22000 | 0.776 | 17072 |
| Wire for espalier (other manufacturer) | Tradable | kg | 750 | 593 | | | | | 750 | 0.791 | 593 |
| Poles | Tradable | number | 2500 | 1978 | | | | | 2500 | 0.791 | 1978 |
| Bags | Tradable | number | 8 | 6 | | | | | 8 | 0.791 | 6 |
| Fertilizer mixture (Chemical) | Tradable/ Import | kg | 337.5 | 186 | 18% | 286 | | | 286 | 0.650 | 186 |
| Fertilizer mixture (Chemical) | Tradable/ Import | kg | 210 | 116 | 18% | 178 | | | 178 | 0.650 | 116 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fertilizer mixture (Chemical) | Tradable/ Import | kg | 500 | 275 | 18% | 424 | | | 424 | 0.650 | 275 |
| Fertilizer mixture (Chemical) | Tradable/ Import | kg | 200 | 110 | 18% | 169 | | | 169 | 0.650 | 110 |
| Insecticide (Chemical) | Tradable/ Import | Bottle/Litter | 4400 | 2154 | 18% | 3729 | 331 | 83 | 3315 | 0.650 | 2154 |
| Insecticide (Chemical) | Tradable/ Import | Bottle/Litter | 3500 | 1714 | 18% | 2966 | 264 | 66 | 2637 | 0.650 | 1714 |
| Insecticide (Chemical) | Tradable/ Import | Bottle/Litter | 2300 | 1126 | 18% | 1949 | 173 | 43 | 1733 | 0.650 | 1126 |
| Insecticide (Chemical) | Tradable/ Import | Bottle/Litter | 3600 | 1763 | 18% | 3051 | 271 | 68 | 2712 | 0.650 | 1763 |
| Insecticide (Chemical) | Tradable/ Import | Bottle/Litter | 1700 | 832 | 18% | 1441 | 128 | 32 | 1281 | 0.650 | 832 |
| Weedicide (Chemical) | Tradable/ Import | Bottle/ml | 8 | 4 | 18% | 7 | | | 7 | 0.650 | 4 |
| Fungicide (Chemical) | Tradable/ Import | Bottle/Litter | 3828 | 1874 | 18% | 3244 | 288 | 72 | 2884 | 0.650 | 1874 |
| Application cost | Non tradable | Tank | 300 | 217 | | | | | 300 | 0.722 | 217 |
| Male labour (Surplus labour) | Non tradable | md | 3000 | 2166 | | | | | 3000 | 0.722 | 2166 |
| Female labour (Surplus labour) | Non tradable | md | 2500 | 1805 | | | | | 2500 | 0.722 | 1805 |
| Guava (other agriculture) Grade 1 | Tradable | kg | 400 | 289 | | | | | 400 | 0.723 | 289 |
| Guava (other agriculture) Grade 2 | tradable | kg | 100 | 72 | | | | | 100 | 0.723 | 72 |

Source: University of Bradford and Ministry of Finance and Planning of Sri Lanka, 1990

Table 15: Conversion factors for guava production with existing technology

| Item | Type | Unit | Unit Price (LKR) | | 1) Eliminate transfer payments (VAT) | | 2) Elimination of duty and subsidies | | | CF | Final |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Financial | Economic | VAT (18%) | Excl. VAT | PAL =10% | SSL =2.5% | Final | | |
| Disc plough 1 for land preparation (Average CF) | Non tradable | acre | 25000 | 19625 | | | | | 25000 | 0.785 | 19625 |
| Disc plough 2 for land preparation (Average CF) | Non tradable | acre | 25000 | 19625 | | | | | 25000 | 0.785 | 19625 |
| Backhoe for land preparation (Average CF) | Non tradable | hr | 1300 | 1021 | | | | | 1300 | 0.785 | 1021 |
| Planting material (other agriculture) | tradable | plant | 175 | 127 | | | | | 175 | 0.723 | 127 |
| Compost (other manufacture) | tradable | kg | 30 | 24 | | | | | 30 | 0.791 | 24 |
| Irrigation cost for energy | Non tradable | Lumpsum | 1667 | 1294 | | | | | 1667 | 0.776 | 1294 |
| Electric water pump (2 hp) | tradable | Lumpsum | 22000 | 17072 | | | | | 22000 | 0.776 | 17072 |
| Bags | tradable | number | 2 | 2 | | | | | 2 | 0.791 | 1.582 |
| Fertilizer mixture (Chemical) | Tradable/ Import | kg | 180 | 99 | 18% | 153 | | | 153 | 0.650 | 99 |
| Insecticide (Chemical) | Tradable/ Import | Bottle/Litter | 4300 | 2105 | 18% | 3644 | 324 | 81 | 3239 | 0.650 | 2105 |
| Weedicide (Chemical) | Tradable/ Import | Bottle/ml | 2000 | 1102 | 18% | 1695 | | | 1695 | 0.650 | 1102 |
| Application cost | Non tradable | Tank | 300 | 217 | | | | | 300 | 0.722 | 217 |
| Male labour (Surplus labour) | Non tradable | md | 3000 | 2166 | | | | | 3000 | 0.722 | 2166 |
| Female labour (Surplus labour) | Non tradable | md | 2500 | 1805 | | | | | 2500 | 0.722 | 1805 |
| Guava (other agriculture) Grade 1 | tradable | kg | 400 | 289 | | | | | 400 | 0.723 | 289 |
| Guava (other agriculture) Grade 2 | tradable | kg | 200 | 145 | | | | | 200 | 0.723 | 145 |

Source: University of Bradford and Ministry of Finance and Planning of Sri Lanka, 1990

Table 16: Cash flows of economic analysis of an acre of guava cultivation with new improved technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Land preparation | 110,726 | | | | | |
| Planting material (seedlings) | 53,213 | | | | | |
| Labour cost for planting | 4,332 | | | | | |
| Mini sprinkler irrigation system per acre | 115,403 | | | | | |
| 2 hp electric pump | 17,072 | | | | | |
| Construction of espaliers | 838,368 | | | | | |
| Cost for irrigating guava | 73,027 | 73,027 | 73,027 | 73,027 | 73,027 | 73,027 |
| Cost for applying fertilizer | 72,899 | 134,581 | 163,831 | 163,831 | 163,831 | 163,831 |
| Cost for weed control | 181,416 | 181,416 | 181,416 | 181,416 | 181,416 | 181,416 |
| Insect control expenditure | 39,339 | 39,339 | 39,339 | 39,339 | 39,339 | 39,339 |
| Cost for managing fungal diseases (Rs) | 20,158 | 20,158 | 20,158 | 20,158 | 20,158 | 20,158 |
| Cost for pruning practices | 26,714 | 52,489 | 69,817 | 78,481 | 78,481 | 78,481 |
| Cost for bagging fruits. | | 57,292 | 666,906 | 945,055 | 1,333,812 | 1,366,344 |
| Cos for harvesting | | 9,415 | 38,988 | 92,705 | 121,296 | 146,999 |
| Depreciation of sprinkler system, pump and espalier at 10% | | 97,084 | 97,084 | 97,084 | 97,084 | 97,084 |
| **Cash outflow** | **1,552,667** | **664,802** | **1,253,483** | **1,594,012** | **2,011,361** | **2,069,596** |
| **Cash inflow (Revenue of guava)** | **-** | **533,719** | **2,490,012** | **5,882,617** | **7,765,020** | **9,416,352** |
| **Net cash flow** | **(1,552,667)** | **(131,083)** | **1,236,529** | **4,288,605** | **5,753,659** | **7,346,756** |

Table 17 Cash flows of economic analysis of an acre of guava cultivation with existing technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Land preparation | 49,455 | | | | | |
| Planting material (air layering) | 75,915 | | | | | |
| Compost | 2,373 | | | | | |
| Labour cost for planting | 7,220 | | | | | |
| 2 hp electric pump | 17,072 | | | | | |
| Cost for irrigating guava | 192,052 | 192,052 | 192,052 | 192,052 | 192,052 | 192,052 |
| Cost for applying fertilizer | 81,657 | 183,963 | 183,963 | 183,963 | 183,963 | 183,963 |
| Cost for weed control | 234,152 | 234,152 | 234,152 | 234,152 | 234,152 | 234,152 |
| Insect control expenditure | 72,191 | 419,003 | 419,003 | 419,003 | 419,003 | 419,003 |
| Cost for pruning practices | | 14,440 | 64,980 | 129,960 | 151,620 | 151,620 |
| Cos for harvesting | | 3,610 | 8,664 | 14,440 | 28,800 | 50,540 |
| Depreciation of water pump at 10% | | 1,707 | 1,707 | 1,707 | 1,707 | 1,707 |
| **Cash outflow** | **732,088** | **1,048,928** | **1,102,815** | **1,173,571** | **1,209,591** | **1,231,331** |
| **Cash inflow (Revenue of guava)** | | **142,431** | **683,669** | **1,139,448** | **2,051,006** | **3,988,068** |
| **Net cash flow** | **(732,088)** | **(906,497)** | **(419,146)** | **(34,123)** | **841,416** | **2,756,737** |

### 7.3 Banana – Cavendish

#### 7.3.1 Banana -Technical Superiority of New Agronomic Practices Introduced by ASMP

1. Land preparation
   Field preparation consists of land tillage, composting, levelling, providing adequate drainage canals, and preparing planting holes.

   The ASMP has introduced a specific procedure for land preparation: land tillage, composting, and levelling. The initial land preparation is implemented with the Mould Board Plough (MBP) /Disc Plough using a 60 cm diameter disk plough. Deep ploughing is done in one direction and the next run is done perpendicular to the first direction after adding the Compost @ 5t /ac. However, most tractor operators do not have MBPs and use only the disc plough and disc harrows. Therefore, the initial tillage is done with the Disc Plough. The purpose of such a procedure is to achieve a uniform planting media with adequate organic manure and also to achieve a uniform depth of soil, facilitating easy drainage and outflow.

   The next step would be to break the clods into a finer structure and level the field with the disc harrow running in one direction and another running perpendicular to it with disks having a diameter of 40 cm. This will enable the field to reach the finer tilth that will be suitable for planting. About 100% of the farmers have adopted the procedure and are content with it.

2. Drainage improvement
   It is recommended to provide an adequate canal system to facilitate in-field and out-of-field drainage, depending on the slope of the land and the texture of the soil. 100% of the farmers have adopted the procedure and are happy with the impact of the better drainage of the fields.

3. Preparation of planting holes
   Planting holes will be prepared only for the size of the propagule as the soil is loosened and composted to accept it.
   Observations:
   1) The recommended steps of new technology are not adopted in existing technology of banana cultivation. The general practice of field preparation for new banana planting in existing technology is to clear the lands of weeds and trees and dig planting holes of 60x60x60 cm at the specified spacing. The soil dug out from the hole is mixed with compost and laid back, after which the plant is planted at an elevated level. The rest of the land is left fallowed and periodically weeded. In this manner, compost will be required only for the volume of the planting hole but not the rest of the area.
   2) As applied in new technology, it is a waste of compost when applied to the rest of the area which will provide nutrients for weed growth unless covered with black plastic mulch. Therefore, intercrop is compulsory in the new technology to use the compost applied to the entire field, along with the plastic mulch that will reduce weed growth and conserve soil moisture.
   3) It is reported that around Rs. 114,000 is spent for field preparation of Banana in new technology on ½ ac while in the existing technology, the cost for digging holes for 40-50 planting holes of the same extent and filling with soil after mixing with compost may cost around Rs. 15000.
   4) Despite the cost difference between the new and existing technology, the lack of such standard practices in existing technology as against new technology may affect the plant growth and production cycle and the final yield.

5) The benefits of field preparation of new technology can be reaped only if the high-income generating intercrop is maintained within banana rows with plastic mulch and micro-irrigation.

4. Planting

In the new technology, planting is done in a hole of the identical size of the plant bag or the propagule.

5. Planting material

In the new technology, extra care is taken in selecting planting material suitable for particular varieties because that will reflect in the productivity of the plantation. Planting material differs with the variety. For kolikuttu and Cavendish varieties, tissue-cultured plants are used, while for Ambul banana, peepers that were extracted from healthy plants and matured for 03 months in a nursery are used.

In contrast, in the existing technology, such selective procedures are not adopted but always use suckers for planting, irrespective of the variety. This approach is liable to carry plant-resident viruses and spread into new areas, affecting the yield.

6. Planting on the field

In the new technology, the double row planting method is used with 1 m between rows and 1.75 m within a row, Double rows are separated by 4 m spacing, which will facilitate tractor movement and transport of bunches. Within the double row configuration, plants are planted within each row in tandem with adjoining row planting so that the plant can capture sunlight at the highest efficiency when grown to the maximum canopy spread. This will give space for 4500 plants per ha (4 plants within (4m+1m)x1.75m=8.75 sqm.; 10000 sqm/8.78 sqm= 4500)

In the existing technology, plants are planted in single rows 4m apart, while within the row plants are planted 3m apart. This will enable around 800 plants per ha planting. However, another recommendation is available where virus diseases are prevalent for planting at a 2m distance between and within rows, which will be useful. The latter method is adopted to remove the entire plantation within 1 year and replant again.

According to the number of plants, the new technology is deemed to give a higher number of bunches, at least 5 times higher than existing technology. Also, the alley width facilitates frequent transport of bunches by tractors on a large plantation.

7. Irrigation

In the new technology, it is compulsory that micro irrigation, preferably micro sprinklers be used for irrigation, irrespective of the intercrop. The irrigation rate is decided according to the daily evaporation (evapotranspiration) applied in 3 cycles per week. An agro well and a water pump are essential components of the irrigation system.

However, farmers are reluctant to use the micro irrigation systems when surface canal gravity water is available in major irrigation schemes. The latter is happening purely due to economic reasons because they have free-flowing water. However, they have agro wells and would pump with the hose at a time of water scarcity.

In the existing technology, irrigation is performed by pumping from the agro well and applying through the hose with almost flood irrigation of the field. The amount of water is not quantified, and there is no technical basis for the amount or time of application. This irrigation practice will tend to wet the soil profile to saturation, which is a wasteful practice.

8. Fertilization / Fertigation

In new technology, fertilizer application is expected to be undertaken through the fertigation unit, but the farmers tend to apply fertilizer manually. However, they apply in the required quantity at the recommended time.

In the existing technology, they always apply fertilizer manually, while the quantity per application and time of application vary and are different to the new recommendation.

This shows that even though the recommendation in new technology is to use the fertigation unit, farmers are not willing to depend on that but to manually apply fertilizers.

9. Weed control

   With the new technology, the intercrop of chilli and long bean, along with the plastic mulch, have completely controlled the weed growth. This resulted in almost zero cost on weed control. 100% of the farmers are happy about the fewer problems with weeds.

   In the existing technology, intercrop is not a part of farming and therefore, the farmer has to bear the cost of weed control manually at least once a month.

10. Clump maintenance and plant density control

    In the new technology, only 03 stems are maintained, the mother, the daughter and the granddaughter and the rest are removed as required. Only the peepers are allowed or separated for future expansion of the plantation. Suckers are not allowed to grow or use for planting. A pruning cycle of 6-8 weeks is maintained when only the 40 cms tall suckers are removed. Also, the followers (growing plant stems) are pushed away from the bunch to prevent them from touching and damaging the growing fruits by tying them away from the main stem.

    In the existing technology, there is no such regular and scientific sucker removal method is adopted but allows at least 3-4 suckers to grow at a time. This results in energy spent on unnecessary growth of suckers and stems reducing the yield.

11. Stem maintenance and bunch clearing

    Stems are vulnerable to collapse due to the weight of the leaves and the bunch. In the new technology, the stems are supported to stay erect by placing the props, guys and aerial cables. This will prevent the collapse of stems, which will happen not only due to the weight of the treetop but also due to heavy winds.

    Also, in the new technology, dry leaves are regularly removed to prevent any harbouring of pests and diseases, while the placenta leaves are bent away to enable more sunlight to fall on the crown.

    In the existing technology, such stem supports are not given, resulting in the collapse of stems with the immature bunch, resulting in yield loss and economic loss as well. Also, in existing technology, the removal of dry leaves or bending of placenta leaves is not done regularly or not removed at all until the bunch is mature. This will result in the vulnerability of the plants to diseases and pests.

12. De-flowering, de-budding and de-handing

    The new technology is to remove the tip of the flowers as soon as the hands are formed and remove buds and false hands, which will compete for nutrition while harbouring insects and diseases. This will ensure nutrition flow to successful fruits to enlarge evenly.

    In the existing technology, this practice is not adopted which will result in uneven development of fruits and waste of fruits when ripe.

13. Intercropping

    All farmers have reported the benefits of intercropping in the new technology, such as control of weeds and additional income from them during the initial 3 years. Intercropping is practiced in Walawa /Sevanagala and Rajangana but not in Jaffna. Chilli was the main crop considered as the intercrop. The Chilli crop is irrigated with drips while the main banana crop is irrigated with

sprinklers. Plastic mulch is very effective in controlling weeds. The sites selected in Jaffna have been cultivated with banana under an organic concept.
These benefits are not realized in existing technology since intercropping is not a part of banana cultivation.

14. Pest and disease control
    In the new technology, control of pests and diseases is addressed through Integrated Pest Management approaches. The farmers have been trained to identify pests and diseases at the very early stages and take necessary steps to control them, including the selection of planting material. Also, they are trained to handle the bagging process, which will effectively control the pest damage.
    In the existing technology, the bagging process is absent, but the pheromone trap for fruit fly is the most common pest control approach. Therefore, the fruits in existing technology are more prone to pests and diseases and resulting in yield losses.

15. Bagging
    In the new technology, bagging is necessarily adopted for the conservation of fruits and preventing them from pest damage. Blue coloured, 90cm diameter, 155cm long PE bags are used to envelop the bunch. The bags are perforated with 12.7 mm, 76mm apart for air exchange and breathing by the unripe bananas. Two methods of bagging are used, such as early bagging before hands are formed and at the time the last hands are formed. The former is preferred since the developing fruits are exposed to blue colour from the beginning, which will result in uniform growth.
    In the existing technology, inserting fruits into the bags was not performed earlier, but later understanding the damages by the insects, the farmers started to insert the fruits in blue coloured PE bags.

16. Management of fruit inventory
    Tree identification and nomenclature (blocking and tagging) are important in identifying the origin of fruit for export purposes. In the new technology, this aspect is emphasized as compulsory. However,
    This concept is not taken in existing technology.

17. Harvesting
    Use of coloured ribbons and callipers
    The use of coloured ribbons is recommended in new technology for deciding on the age of the bunch in order to harvest at the ideal stage. Also, callipers are used to define the ideal state of maturity of the fruits. The fruit diameter defined for Ambul banana is 30mm at 10-12 weeks stage, while the diameter for Cavendish is defined as 36mm at the 11-13 weeks stage.
    In the existing technology, such defined measuring technology is not used, but the visual observation of fruits becoming lighter green. This will result in the harvest of immature fruits, reducing the price for the bunch and the fruits.
18. Defining the number of leaves at harvest
    In the new technology, it is recommended to leave a maximum of 6-7 leaves before harvest time so that shade and top weight are reduced.
    In the existing technology, such management techniques are not used but leave all the old leaves on the plant until the harvest.

### 7.3.2 Cavendish Banana - The New Technology Package

The ASMP has introduced two technological packages for banana cultivation quality enhancing technology and new improved technology. In this assignment, the Sevenagala Cavendish banana cluster is selected to study the Cavendish banana crop. The ASMP advised farmers from the Sevenagala Cavendish cluster to cultivate Cavendish banana in a half-acre each and they were provided with some materials relevant to the introduced new technology free.

Table 18: Data relevant to the new technology package for Cavendish Banana

| Main Technology - New Technology marked in blue | Practice | Expected Results |
|---|---|---|
| Tissue cultured meristems | **Procuring from the local nurseries** | Cost of planting materials. Even crop growth |
| Land preparation – New Technology | Deep ploughing using a Disk Plough of 60 cm diameter or mouldboard plough | Reduced loss of water, nutrients and healthy plants consequently reduces the cost of production. |
| | Application of compost | |
| | Deep ploughing using a Disk Plough of 60 cm diameter or mouldboard plough(perpendicular to first ploughing) | |
| | Disk plough of 40 cm diameter or harrowing (two perpendicular passes) | |
| | Micro levelling to facilitate drainage works | |
| Mini-sprinkler irrigation systems | Computer-controlled heads for water application scheduling supported by fertility sensors and soil moisture sensors | Reduction of the quantity of water required, reduction of the quantity of fertilizer required, reduction of the quantity of pesticides required, consequently, the reduced cost of production due to the increase in efficiency of liquid application. |
| | Precision fertigation with liquid organic compounds | |
| | Precision application of liquid pesticides | |
| | Anti-clogging flushing components | |
| Flood prevention and drainage - field techniques– New Technology | Site levelling using laser levelling machinery, quick water evacuation ditches, Surface drainage techniques (removal of wet spots) | Reduction of waterlogging and consequent crop losses. Decreased cost of production |
| Precision planting | Construction-type twine to demarcate planting rows, planting templates with plant spacing measurements | Increased plant density, Increased yield and harvest, Increased income |
| Double row planting system– New Technology | Bananas are planted in two double rows 1 m apart. | |
| | The spacing for bananas within a double row is 1.75 m | |
| | An alley, 4 m wide, separates the double Rows. | |
| Multiple cropping | | Increased cropping intensity, Increased income |
| Weeding | | Mechanical weeding prevents environmental problems. |
| Precision Fertilization | Fertigation with organic liquid fertilizers | Reduced quantity of fertilizer, |

| | | |
|---|---|---|
| | supplemented with fertilization and/or fertigation with chemical fertilizers | reduced cost of fertilizer. |
| IPM | Pest population and pest damage assessment surveys to evaluate pest and disease intensity/quantity factors for damage prevention and to determine pest population threshold status for rational application of pesticides. | Reduced quantity of pesticide required due to reduction of waste of pesticides Reduced cost of pest control Contribution to environmental protection |
| | Prevention and management of Fusarium wilt (Panama disease) | |
| | Control of Sigatoka disease and other pre and post-harvest diseases | |
| Labelling for precision agriculture | Production area blocks and tree tagging labelling | Reduction of waste of products, Reduction of cost of production, Reduction of waste of inputs (material and time), Contribution to environmental protection |
| Bunch clearing before bagging – New Technology | Removing leaves that can damage bunch and bending or removal of placenta leaf | Reduction of damage to a banana bunch |
| Bagging with plastic bags | Bagging when the bunch is just emerging and the centre flower bud points downward | Well-grown banana |
| Bunch clearing after bagging – New Technology | De-leafing, de-flowering, de-handing, disbudding | Reduction of fungal damage, insect damage and abrasion injury on fruit skin. Quality banana and increased harvest/ yield |
| Tagging of the banana bunch with coloured plastic ribbons – New Technology | Every week, a different coloured ribbon is applied when the lower hands are parallel to the ground. Eight colours are used. | A better market price, no marketing issues compared to before implementing this technique, |
| Propping and guying ribbons – New Technology | The banana bunch is propped with wooden poles tied with rope or plastic | Reduction of damage in the field |
| Harvesting by De-handing at the Mat – New Technology | Bunches for de-handing in the field are selected based on age (ribbon colour) and calliper grade to protect the quality, prevent ripening and turnings during transport and extend shelf life. | Increased quality of banana Reduced requirement of organic matter |
| | Hands are removed from the bunch using a fish line (100 test) that cuts and seals the crown properly with no additional trimming required. | |
| De-latexing in the | Removed hands from the harvested | Reduced packing time and |

| | | |
|---|---|---|
| field – New Technology | bunch are placed on the banana leaves for de-latexing for at least one hour. | reduced requirement of packing materials |
| Transport to packing centre– New Technology | Packing the de-latexed hands into 20-kg plastic trays lined with foam. One bunch, one crate | Reduction of damage to banana hands |
| | The colour ribbon is tied securely to the crate to allow for inventory management at the packing centre. | |
| Postharvest technology– New Technology | Field heat removal. Line packing, cold chain management Integration of export protocols into standard SOPs | Increased quality of banana, reduced loss of banana, having a better price |

The technology package introduced by the ASMP is compared with the recommendations of the DOA and the average farmer practices are compared in Table 19. In land preparation, the DOA recommendation is for shallow plough depth than the recommendation of the ASMP.

While the ASMP recommend a mini sprinkler system with fertigation, the DOA has recommended drip irrigation without fertigation. The ASMP recommends phytosanitary practices, harvesting and processing in detail, while the recommendations of the DOA are not descriptive enough.

Table 19: Data relevant to the existing technology package for Cavendish

| No | Aspect | Activity | DOA Recommendation | Farmer Practice | Expected Results |
|---|---|---|---|---|---|
| 1 | Land preparation | 1st plough and 2nd plough with 2W or 4W tractors | Deep ploughing to > 20 cm with Disc/MB plough and break into fine tilth | Loosen top 15 cm with tine tiller | Prevent water logging and improve drainage conditions of soil, Damages due to water logging, Soil aeration status, Level of soil fertility, Requirement of application of weedicides, Frequency of application of weedicide |
| | | Preparation of planting pits | 1x1x1 m pits 3-4 m apart; organic matter/compost mixed with soil before planting | 50x50x50 cm at 3-4 m apart with a backhoe; no or less OM mixed before planting | |
| | | Pre-planting weed removal | Manual weeding | Use of weedicides | |
| 2 | Planting | Planting material | 60-100 cm high primary and secondary suckers Tissue cultured plants | Less attention to height and status Tissue cultured plants | Condition of plant, The survival rate of plants, Requirement of replacing dead plants, Application of water for plants; |
| | | Planting process | A layer of coconut husk at the bottom overlayed with soil | Rarely coconut husk laid; rarely OM is mixed; | |

| | | | | | |
|---|---|---|---|---|---|
| | | | mixed with OM and planting the sucker in the centre 15 cm below surface level. | plant the sucker at surface level. | frequency, and quantity per plant |
| | | Variety | Ambul; seeni; kolikuttu | Ambul; seeni; kolikuttu | |
| 3 | Irrigation | Source | Irrigation canal or agro well | Irrigation canal or agro well | Water requirement per plant, Frequency of watering, |
| | | Method of water supply | Surface canal/gravity Drip irrigation | Surface canal/gravity Drip irrigation | |
| | | Frequency | Once/7 days | Once/10-14 days | |
| | | Quantity | Unmeasured | Unmeasured | |
| 4 | Fertilizing | Organic matter /compost | Only at planting | Not applied | Time of applying fertilizer for plants and type of fertilizer, Quantity of fertilizer at different ages of a plant |
| | | Chemical fertilizers | N:P:K as recommended | N:P:K as perceived | |
| | | Frequency | As recommended | As perceived | |
| | | Quantity | As recommended | As perceived | |
| 5 | Weed control | Mechanical | Manual | Manual | Type of weed control method applied, Quantity of weedicide if applied weedicides, Frequency of implementing weed control methods |
| 6 | Pest control | Pesticides | As required | As required | Type of pest, type of pest control methods applied for each pest, Type and quantity of pesticide if applied, Frequency of applying pesticide |
| 7 | Disease control | Removal of plants | As required | As required | Type of disease, type of disease control methods applied Type and quantity |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | of agrochemicals if applied, Frequency of applying disease control measures |
| 8 | Clump management | Removal of excess shoots | 02 suckers allowed | Many suckers allowed | Growth of remaining plants, Size of bunch |
| 9 | Pre-harvest bunch management | Colour PE bagging | Placement of coloured PE bags from the young stage | Not practiced | Growth of banana, Quality of banana, Reduction of possible damages to the banana |
| 10 | Harvesting | Cutting the stem and bunch | As required | As required | Time of harvesting, Quality of banana |
| | | Stage of harvest | As required | When the fruits are big but immature | |
| 11 | Post-harvest processing | Storage | Bunch as it is | Bunch as it is | Possible damages, damages to banana, quality of banana |
| | | Transport | Bunch as it is | Bunch as it is | |
| 12 | Field sanitation /removal of left-over | Removal of left-over stems and other pieces | Keep the stem pieces away from the clump to attract weevil | Less attention to the removal of left-over | Reduction of pest incidences |

### 7.3.3 Adoption of the Quality Enhancing Technology - Sevanagala Cavendish Cluster

Table 20 presents information on the adoption of the quality enhancing technology by the farmers from the Sevanagala Cavendish cluster. All of the interviewed farmers (100%) adopt bunch clearing before and after bagging, tagging, and propping. According to farmers, they have been able to improve the appearance and quality of Cavendish banana by adopting these practices of quality enhancing technologies. The peel of the Cavendish banana is comparatively soft and damaged leaves can cause abrasions affecting its appearance. Further, the remaining flower buds can support fungal attacks. Therefore, bunch clearing practice is important for producing quality banana. According to farmers' responses to the benefits of bunch clearing practice, farmers agree that bunch clearing is useful for producing quality banana. It shows that most of the interviewed farmers accept and adopt these practices of quality enhancing technology.

Out of the interviewed farmers, 80% (4) practice de-handling with fish line and de latexing as they sell their product to the packing centre. 20% do not practice as they sell their product to buyers coming to their field and buying bunches. No farmer has reported following postharvest technology.

Table 20: Practices of quality enhancing technology introduced by the ASMP for Cavendish banana

| Introduced Practices | | % of the adopted farmers | Remarks |
|---|---|---|---|
| Bunch clearing before bagging | Removing leaves that can damage bunch and bending or removal of placenta leaf | 100% (5) | Preventing abrasion on banana peel |
| Bagging with plastic bags | Premature bagging when the bunch is just emerging and the centre flower bud points downward | 100% (5) | Preventing damage to banana |
| Bunch clearing after bagging. | De-leafing, de-flowering, De-handing, de-budding | 100% (5) | Preventing possible fungal growth |
| Tagging of the banana bunch with coloured plastic ribbons | Every week a different coloured ribbon is applied when the lower hands are parallel to the ground. Eight colours are used | 100% (5) | Important to manage the harvest |
| Propping and guying | The banana bunch is propped with wooden poles tied with rope or plastic | 100% (5) | The Cavendish stem is not strong enough to bear well-grown banana bunches |
| Harvesting by de-handing at the Mat | Bunches for de-handing in the field are selected based on age (ribbon colour) and caliper grade to protect quality, prevent ripening and turnings during transport and extend shelf life | 80% (4) | 20% of farmers do not adopt as buyers get bunches |
| | The hands are removed from the bunch using a fish line (100 test) that cuts and seals the crown properly with no additional trimming required | 80% (4) | |
| De-latexing in the field | Removed hands from harvested bunch are placed on banana leaves for de-latexing for at least one hour | 80% (4) | |
| Transport to packing centre | Packing the de-latexed hands into 20-kg plastic trays lined with foam.<br>One bunch, one crate | 80% (4) | |
| | The colour ribbon is tied securely to the crate to allow for inventory management at the packing centre. | | |
| Postharvest technology | Field heat removal Line packing Cold chain management | 0 | 100% not adopted as they do not have |

| | | | |
|---|---|---|---|
| | Integration of export protocols into standard SOP's | | such facility |

Table 21: Farmers' response to the benefits of bunch clearing practice

| Technological Practice | Benefits of the practice | Farmers response |
|---|---|---|
| Bunch clearing before bagging and plastic bags | Protection of fruits from sunburn, hot wind and dust | 80% (4) |
| | It has an attractive colour – therefore, better market price | 60% (3) |
| | Yield increases of 15% - 20% | 60% (3) |
| | Preventing main stalk rot | 80% (4) |
| | Avoiding fingertip disease due to removal of infection by saprophyte fungi | 80% (4) |
| | Appearance is good, and buyers buy | 20% (1) |
| Bunch clearing after bagging | Reduction of fungal damage | 80% (4) |
| | Reduction of insect damage | 20% (1) |
| | Reduction of abrasion injury on fruit skin | 80% (4) |
| | Quality banana (appearance is good) | 100% (4) |

### 7.3.4 Adoption of the New Technology - Sevanagala Cavendish Cluster

Table 22 indicates the practices of the new technology package the ASMP introduced for banana and the percentages of the interviewed farmers adopting these practices. As per the table, some of the introduced practices have been adopted.

The first practice of the table is related to the planting material of Cavendish. The project has supplied the tissue-cultured plant to the selected farmers free. All farmers were growing Ambul banana until the ASMP project introduced Cavendish banana to Sevenagala farmers.

As shown in Table 22, deep ploughing is practised twice using a disc plough, adding compost, harrowing and micro levelling. All the interviewed farmers (100%) adopted 1$^{st}$ deep ploughing and harrowing. Out of the farmers adopting the first deep ploughing, 80% adopt the second deep ploughing and 60% adopt micro levelling with a backhoe. Out of the interviewed farmers, 60% adopt the whole package while 40% of the farmers do not adopt all practices of the soil preparation package.

A mini sprinkler irrigation system has been provided free to all the farmers of this Cavendish cluster. All of the interviewed farmers irrigate Cavendish cultivation with this sprinkler irrigation system.

A fertigation technique has been introduced to apply both liquid organic fertilizer and chemical fertilizer. Out of the interviewed farmers, 60% practised within the first nine months and the other 40% practised within the first six months after planting. Thereafter, no one has been adopting fertigation as the farmers think that the quantity of fertilizer applied through fertigation is insufficient.

All of the interviewed farmers adopt practices such as flood prevention and drainage techniques, precision planting and double row systems, which have been useful for increasing harvest. Farmers appreciate double row planting because farmers could increase their harvest and income. With this practice, plant density has increased and there is a considerable land space between two banana beds. Chilli has been cultivated as an intercrop by 80% of the interviewed farmers once and they have had a better income which could cover their initial cost. However, farmers have not continued it as they are busy with other activities.

Bagging fruits is another practice the ASMP introduced. Initially, the ASMP provided bags. All farmers practice bagging banana bunches as it prevents fruits from physical damage and pest attacks. Further, bagging causes the production of quality banana which can be sold at a higher price.

Table 22: Farmers adopting practices of new technology introduced by the ASMP for Cavendish banana

| Introduced Practices | | % of the adopted farmers | Remarks |
|---|---|---|---|
| "Peeper" planting material | Banana seedlings developed from "peepers" taken from the production field and grown for 3 months following nursery practices. | | Cavendish banana cluster has been provided tissue culture plants. |
| | Peepers should reach approximately 40 cm in height, with 4 to 5 functional green. leaves present to be ready for transplanting | | |
| | Tissue culture plants provided by ASMP | 100% (5) | |
| Land preparation | Deep ploughing using a mouldboard plough | 100% (5) | |
| | Application of compost | 100% (5) | |
| | Deep ploughing again using mouldboard plough (perpendicular to first ploughing) | 80% (4) | |
| | Disking or harrowing (two perpendicular passes) | 100% (5) | |
| | Micro levelling to facilitate drainage and forming drainage canals with a backhoe and manually | 60% (3) | Laser equipment is not used for microlevel ling |
| Mini-sprinkler irrigation systems | Precision fertigation with liquid organic Compounds | 80% (4) | Fertigation was practised with chemical fertilizers within the first 6 months by 40% and 9 months by 60%. No organic liquid compounds are used. Thereafter, farmers do not practice as |
| | Anti-clogging flushing components | 60% (3) | |

| | | | |
|---|---|---|---|
| | | | farmers think that a sufficient quantity of fertilizer cannot be applied through fertigation. |
| Flood prevention and drainage field techniques | Site levelling using laser levelling, machinery, quick water evacuation ditches, surface drainage technique, machinery, (removal of wet spots) | 100% (5) | Farmers are not aware of the laser technology etc, but they manually take steps to remove any flood water. |
| Precision planting | Construction type twine to demarcate planting rows, planting templates with plant spacing measurements | 100% (5) | |
| Double row planting system | Bananas are planted in two double rows 1m apart | 100% (5) | |
| | The spacing for bananas within a double row is 1.75 m | 100% (5) | |
| | An alley, 4 m wide, separates the double Rows | 100% (5) | |
| Multiple cropping | Intercrop cultivation | 80% (4) | 20% have not been cultivated. Others have cultivated only once. |
| Precision fertilization | Fertigation with organic liquid fertilizers supplemented with fertilization and/or fertigation with chemical fertilizers | 40% (2) | 20% of the people interviewed have practiced fertigation for the first 6 months and another 20% have practiced it for 9 months. 20% of the interviewed have not practiced it at all. These farmers think that fertilizers applied through fertigation is not sufficient. |
| Pest and disease control based. on IPM practices and modern | Pest population and pest damage surveys to assess pest threshold status for the application of pesticides. Pest population and pest damage surveys to assess pest threshold status for the application of pesticides | 0 | None of the people interviewed reported that they are practising pest control methods. |
| | Prevention and management of | 60% (3) | Banana cultivation |

| | | | |
|---|---|---|---|
| spray techniques | Fusarium wilt (Panama disease) fungicide mixtures | | of 40% of the interviewed is not expected to be affected by these diseases due to well drained soils. |
| | Control of Sigatoka disease and other pre and postharvest diseases | | |
| Labelling/ bagging for precision agriculture practices | Bagging and tree tagging | 100% (5) | This practice is useful for protecting banana improving the quality of banana and managing harvesting. |

### 7.3.5 Practices of the Existing Technology of Cavendish Cultivation

Farmers who cultivate Cavendish banana prepare the land by doing one deep ploughing and levelling with rotary. They irrigate the crop by flooding the field. Plants are mostly bought from other existing banana farmers. Existing farmers do not plant in the double-row system and the number of plants required varies from 375 to 400 for 0.5 acre. They apply fertilizer manually and use pesticides and weedicides when required. All practice propping as the Cavendish banana stem is not strong enough to bear bunches. These farmers do not adopt de-handing and bunch clearing and bunches are sold when maturity is enough to harvest.

**Utilization of input**

Table 23 shows the average amount of some of the inputs currently utilized for growing Cavendish banana per acre per year using the new technology and existing technology, amounts of all input items utilized for cultivating Cavendish with the new technology are greater than those utilized for cultivating Cavendish with the existing technology.

According to the information given in Table 23, a mini sprinkler irrigation system is used to irrigate Cavendish and the average annual volume of water (2,331,225 lit) used to irrigate 0.5 ac is greater than the volume of water (2,000,000lit) used to irrigate 0.5 ac of Cavendish by the existing farmers.

Thus, the average annual labour used for irrigating 0.5 ac of Cavendish cultivation under the sprinkler irrigation system is negligible because farmers have to just operate sprinklers. The existing farmers practice of flood irrigation requires diverting water and farmers have to fully attend for irrigation with manual labour. The average annual amount of labour used to irrigate Cavendish through flood irrigation is 80 man-days under the existing method.

A mini sprinkler system is a component of the new improved technology package. As a sprinkler system has been installed in a Cavendish banana field, the only action a farmer has to do when required to irrigate is to keep the pump operating for a required time period.

Under existing farmer practice with flood irrigation, a farmer happens to divert water from one plot to another by blocking and unblocking drains in the field. Therefore, farmers who adopt existing technology happen to spend more time in the field when irrigating compared to those who adopt the new technology. Further, farmers who irrigate with a mini sprinkler system can be involved in other works such as weeding, bagging and bunch clearing while irrigating. In fact, time spent on irrigation under the new technology is negligible.

Thus, the cost of energy (Rs. 66,138/=) for irrigation of the new improved technology package for Cavendish banana is higher than that (Rs. 37,333/=) of the existing technology as more energy is required for pumping more water. However, the total irrigation cost (energy cost and labour cost) incurred in irrigating Cavendish under the existing practice is as high as Rs. 100,333/=. If the solar-powered irrigation system is used, irrigation costs can be brought down to zero with improved technology and also reduced with existing technology.

As depicted by Table 23, the quantity of fertilizer used under the improved new technology package is 954.25 kg per 0.5 acre for a year and fertilizer quantity under existing technology is 622.50 kg per 0.5 acre for a year. The average annual fertilizer cost under the new technology and the existing technology for 0.5 acre Cavendish cultivation is Rs. 162,678/= and Rs. 100,485/= respectively. Farmers do not follow advice given by the ASMP regarding fertilizer application and they think that fertilizer applied through fertigation is not sufficient for crop growth and it is necessary to apply fertilizer to each plant by hand. When fertigating, fertilizer dissolved in water spreads over the field and is not properly applied and utilized for each plant. The manual application of fertilizer incurs a labour cost. The average annual labour used to apply fertilizer for 0.5 acre of Cavendish cultivation under the new improved technology and the existing technology is 21.5 man-days and 15.5 man-days respectively while labour cost regarding the former is Rs. 64,500/= and the latter is Rs. 38,750/=.

Table 23: Average quantities of some inputs currently utilized for growing Cavendish banana per 0.5 acre per year using the new technology and existing technology

| Item | Unit | New Technology | Existing Technology |
|---|---|---|---|
| Average volume of water irrigated | litre | 2,331,225 | 2,000,000 |
| Average number of labour utilized for irrigation | Man day | Negligible | 80 |
| Average annual energy cost for irrigation | Rs. | 66,138 | 37,333 |
| Average annual labour cost for irrigation | Rs. | Negligible | 64,000 |
| Average quantity of fertilizer utilized | Kg | 954.25 | 622.5 |
| Average number of labour units utilized for applying fertilizer | Man day | 21.5 | 15.5 |
| Average annual fertilizer cost | Rs. | 162,678.6 | 100,485.7 |
| Average annual labour cost for applying fertilizer | Rs. | 64,500 | 38,750 |

### 7.3.6 Cavendish Banana Production with the New Improved Technology and the Existing Technology

Cavendish banana takes about 9 months after planting to reach the flowering stage and another three months to reach maturity enough for harvesting. Therefore, the Cavendish banana can be harvested within the first year after planting. The average weight of a bunch of Cavendish banana is 12 to 15 kg. Table 24 presents changes in average annual production and average revenue of Cavendish banana per 0.5 ac over five years with the new improved technology and existing technology. Sevenagala Cavendish cluster has been functioning for two years and farmers can predict future harvest according to clump management (Box -02).

The effects of all practices of both the new improved and existing technologies can be observed in fruit production. Therefore, Cavendish production corresponding to these two technology packages can be taken as an indicator to evaluate the superiority of the technology packages.

As shown in Table 24, the average annual production of Cavendish banana per 0.5 ac with the practices of the improved new technology is higher than that with the existing technological practices over a year. One of the practices which is directly linked with production increase is the double row planting pattern of the new improved technology, which increases Cavendish plant density. Plant density with the new improved technology is 480 plants per 0.5 acre while that is 375 plants per 0.5 acre with the existing technology.

Average annual Cavendish production with the new improved technology package increases from 3,873 kg per 0.5 acre in the first year to 8,597 kg per 0.5 acre in the third year. After the second year, harvest becomes constant and continues for the fourth and fifth years. The existing technology increases from 2,100 kg per acre (1050 kg/0.5 ac) in the first year to 7,800 kg per acre (3900 kg/0.5 ac) in the second year and thereafter harvest is constant. Generally, 5% of the total harvest is damaged due to falling bunches and other handling activities. The effective harvest (total harvest less damage) sold is considered as earned revenue. The average annual income from Cavendish banana with the new improved technology varies from Rs. 372,226/= to Rs. 846,641/= and that with the existing technology varies from Rs. 197,400/= to Rs. 733,200/= per acre per year as shown above.

Labour and labour costs related to harvest with the new improved technology is also higher than those under the existing technology because production of Cavendish with the new technology is higher than that with the existing technology. Cavendish banana has been introduced to the Sevenagala area by the ASMP and a few farmers who do not belong to the Cavendish cluster also grow Cavendish banana. These farmers have bought Cavendish plants from the Bandagiriya area in Hambantota where Cavendish banana is cultivated.

**Box - 02**
**Yield Forecasting of Cavendish Banana**

Farmers from the Sevenagala Cavendish cluster are allowed to grow three plants in a clump and others are chopped. They maintain clumps according to the new improved technology. According to the interviewed farmers, each plant of a clump is maintained at a 4-month time gap. Therefore, each clump always bears a bunch. When one bunch is harvested, another plant of a clump bears a bunch.

Each farmer cultivates 480 Cavendish plants in 0.5 ac according to the double row planting method. Therefore, 1st harvest is 480 bunches in the 1st year after planting. Farmers reap 1st year harvest within two months. Thereafter, harvest depends on the method of managing clumps and according to farmers, they can harvest every week.

Table 24: Changes in average annual production and average revenue of Cavendish banana per 0.5 acre per year over five years with the new improved technology and existing technology

| | New improved technology - Year | | | | | | Existing technology - Year | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Item** | **1** | **2** | **3** | **4** | **5** | | **1** | **2** | **3** | **4** | **5** |
| Average harvest of Cavendish banana (kg) | 3,873 | 7,957 | 8,597 | 8,597 | 8,597 | | 2,100 | 7,800 | 7,800 | 7,800 | 7,800 |
| Average damage (5%) of harvest of Cavendish banana (kg) | 194 | 398 | 430 | 430 | 430 | | 126 | 468 | 468 | 468 | 468 |
| Average effective harvest of Cavendish banana(kg) | 3,679 | 7,559 | 8,167 | 8,167 | 8,167 | | 1,974 | 7,332 | 7,332 | 7,332 | 7,332 |
| Average value of effective harvest (gross revenue) of Cavendish banana – (Rs) | 372,226 | 770,641 | 846,641 | 846,641 | 846,641 | | 197,400 | 733,200 | 733,200 | 733,200 | 733,200 |
| Average number of labour used to harvest Cavendish (md) | 9.60 | 23.90 | 29.50 | 29.50 | 29.50 | | 3.50 | 13 | 13 | 13 | 13 |
| Average labour cost for harvesting Cavendish (Rs.) | 28,800 | 71,700 | 88,500 | 88,500 | 88,500 | | 10,500 | 39,000 | 39,000 | 39,000 | 39,000 |

### 7.3.7 Cost of Production of Cavendish Banana

The cost of production of Cavendish banana with the new improved technology and the existing technology can be used to compare the efficiency of these two technologies. The cost of production is the cost incurred in producing a kilo of Cavendish banana. Table 25 and Table 26 present changes in effective harvest, cost of cultivation and cost of production of Cavendish banana over five years with the new improved technology and those with the existing technology, respectively.

According to information in Table 25 and Table 26, the cost of production of the Cavendish banana has drastically decreased from the first year to the second year in both cases. From the second year, the cost of production is constant in both cases.

The cost of production of Cavendish with the new improved technology is Rs. 209/kg in the first year and thereafter, it is Rs. 80/kg in the second year and Rs. 78/kg in the third year and onwards. The cost of production with the existing technology is Rs. 257/kg in the first year and Rs. 57/kg in the second year and onwards. Except first year, the cost of production with the existing technology is lower than that with the new improved technology. The cost of cultivation with the new improved technology is higher than that with the existing technology. Although the Cavendish banana harvest with the new improved technology is higher than that with the existing technology, the difference in harvest is lower than the difference in cost of cultivation between two cases. Therefore, farmers who adopt the existing technology have a breakeven at low market price compared to those who adopt the new improved technology. Farmers adopted the new improved technology as the ASMP assisted by bearing a part of initial investment of each member farmer (It is considered that a farmer bears all costs; if the expenditure borne by ASMP is not considered, the cost of production in the first year would be Rs. 119/kg).

Table 25: Changes in the cost of production per 0.5 ac per year of Cavendish banana over five years with the new improved technology

| Year | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Average effective harvest of Cavendish banana (kg) | 3,679 | 7,559 | 8,167 | 8,167 | 8,167 |
| Average cost of cultivation (Rs.)* | 769,412 | 602,025 | 637,950 | 637,950 | 637,950 |
| Cost of production (Rs. per kg)* | 209 | 80 | 78 | 78 | 78 |

*Note: All costs are imputed costs as opportunity cost of family labour is included.

Table 26: Changes in cost of production per 0. Ac per year of Cavendish banana production over five years with the existing technology

| Year | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Average effective harvest of Cavendish banana (kg) | 1,974 | 7,332 | 7,332 | 7,332 | 7,332 |
| Average cost of cultivation (Rs.) * | 507,894 | 419,914 | 419,914 | 419,914 | 419,914 |
| Cost of production (Rs. per kg) * | 257 | 57 | 57 | 57 | 57 |

*Note: All costs are imputed costs as the opportunity cost of family labour is included.

### 7.3.8 Financial analysis

Financial analysis is conducted to ascertain how the project is benefiting to beneficiaries. The following conditions are considered in conducting the financial analysis.

1. The ASMP has provided free land preparation, a mini sprinkler system, planting material and a water pump. These can be considered as subsidies to beneficiaries to motivate them. Generally, subsidies are considered as income in financial analysis. Here, the value of these items is considered a cost to the beneficiaries because the analysis is focused on checking the superiority of technologies and the cost incurred in adopting these technologies should be covered by the project.

2. All taxes such as VAT, PAL, SSL and duties of the imports are included in the market price of these commodities.

3. Inflation of input prices and output prices is not considered. It is assumed that the effect of inflation may be cancelled out

4. Both inputs and Cavendish banana production are valued using existing market prices.

5. Cavendish production starts from the first year and analysis is done for five years.

6. The discount rate used for calculating NPV, Present Values of cost and benefit is the average fixed deposit interest rate (08%).

Table 27 presents FIRR, FNPV and Benefit Cost Ratio relevant to an acre of Cavendish cultivation with the new improved technology and the existing technology. According to Table 27, FIRR for an investment in Cavendish cultivation with the new improved technology is 33% and that is 94% with the existing technology. These FIRR values indicate that 0.5 ac of Cavendish cultivation with the new technology generates benefits at a lower rate (33%) to a beneficiary than that with the existing technology (94%). The present value (at 8%) of net worth generated from 0.5 ac of Cavendish cultivation with the new improved technology is Rs. 0.2379 million per annum while with the existing technology, it is Rs. 0.6733 million per annum. The benefit-cost ratio regarding the new technology is 112% and that for the existing technology is 143%. According to these values criteria, Cavendish farmers do not gain advantages by adopting the new improved technology compared to the existing technology.

Table 27: IRR, NPV and B/C for NT and ET

| Criterion | NT | ET |
|---|---|---|
| FIRR | 33% | 94% |
| FNPV (Rs. million) - at bank fixed deposit rate, 8% | 0.2379 | 0.6733 |
| B/C | 112% | 143% |

### 7.3.8 Issues related to Cavendish Cultivation

According to the interviewed farmers, there is no issue except the market price which is not sufficient to cover the cost of production. If there are ways of reducing the cost of production with the new improved technology such as solar power generation which can reduce irrigation costs, the new technology can be made more useful.

Another way of reducing the cost of production is the application of required quantities of fertilizer through implementing precision fertilization and enhancement of farmer awareness about correct quantities of fertilizer. The cost of fertilization is more than 30% of the total cost of Cavendish cultivation. Percentages of fertilization cost of total production cost with the new improved technology and the existing technology are 35% and 32%, respectively. Precision fertilization requires foliage analysis and soil testing before applying fertilizer which is costly and a technical task. Therefore, the government should provide facilities so that any farmer can have advice for fertilization at an affordable cost.

### 7.3.9. Conclusions

Farmers who adopt the new technology cannot exist when the market price is less than Rs. 80/kg. However, farmers who adopt the existing technology can exist when the market price is less than Rs. 80/kg.

### 7.3.10 Cash Flows of Financial Analysis of Cavendish Banana Cultivation

Table 28: Cash flows of the financial analysis of 0.5 ac of Cavendish banana cultivation with new improved technology

| Year | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Land preparation | 118,200 | | | | |
| Planting material (Tissue culture plant) | 52,800 | | | | |
| Labour cost for planting | 13,500 | | | | |
| Mini sprinkler irrigation system per 0.5 acre | 95,500 | | | | |
| Water pump - 2 inch | 49,000 | | | | |
| Cost for irrigating Cavendish | 66,138 | 66,138 | 66,138 | 66,138 | 66,138 |
| Cost for applying fertilizer | 188,322 | 266,035 | 266,035 | 266,035 | 266,035 |
| Cost for applying organic manure | 22,600 | 22,600 | 22,600 | 22,600 | 22,600 |
| Cost for weed control | 28,280 | 28,280 | 28,280 | 28,280 | 28,280 |
| Insect control expenditure | 5,780 | 5,780 | 5,780 | 5,780 | 5,780 |
| Cost for managing fungal diseases (Rs) | 24,542 | 24,542 | 24,542 | 24,542 | 24,542 |
| Cost for bagging cavendish | 61,500 | 102,500 | 121,625 | 121,625 | 121,625 |
| Cos for harvesting | 28,800 | 71,700 | 88,500 | 88,500 | 88,500 |
| Depreciation of sprinkler system and pump at 10% | 14,450 | 14,450 | 14,450 | 14,450 | 14,450 |
| **Cash outflow** | **769,412** | **602,025** | **637,950** | **637,950** | **637,950** |
| **Cash inflow (Revenue of Cavendish)** | 372,226 | 770,641 | 846,641 | 846,641 | 846,641 |
| **Net cash flow** | **(397,186)** | **168,616** | **208,691** | **208,691** | **208,691** |

Table 29: Cash flows of the financial analysis of 0.5 ac of Cavendish banana cultivation with the existing technology

| Year | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Land preparation | 52,500 | | | | |
| Planting material (Tissue culture plant) | 39,390 | | | | |
| Labour cost for planting | 30,000 | | | | |
| Water pump - 2 inch | 12,000 | | | | |
| Cost for irrigating Cavendish | 101,333 | 101,333 | 101,333 | 101,333 | 101,333 |
| Cost for applying fertilizer | 121,276 | 138,686 | 138,686 | 138,686 | 138,686 |
| Cost for weed control | 82,275 | 82,275 | 82,275 | 82,275 | 82,275 |
| Cost for managing fungal diseases (Rs) | 57,420 | 57,420 | 57,420 | 57,420 | 57,420 |
| Cost for harvesting | 10,500 | 39,000 | 39,000 | 39,000 | 39,000 |
| Depreciation of water pump at 10% | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
| **Cash outflow** | **507,894** | **419,914** | **419,914** | **419,914** | **419,914** |
| **Cash inflow (Revenue of Cavendish)** | 197,400 | 733,200 | 733,200 | 733,200 | 733,200 |
| **Net cash flow** | **(310,494)** | **313,286** | **313,286** | **313,286** | **313,286** |

## 7.4 The New Technology Packages for Ambul Banana Cultivation

Two technological packages introduced by the ASMP for banana cultivation have been adopted by the Ambul banana cluster in Rajangana, which was selected for this assignment. Farmers from the Rajangana Ambul cluster were provided with some material relevant to the new technologies free of charge for a half-acre of Ambul banana cultivation.

The quality management practices introduced by the ASMP for Cavendish banana are equivalent to the Ambul banana. The only difference is the use of peeper planting material for the Ambul banana as described in Table 30, below.

When compared to the DOA recommendations and farmers' practices, Ambul banana did not show any difference to Cavendish banana.

Table 30: Data relevant to quality-enhancing technologies for Ambul Banana

| Main Technology - New Technology Marked in Blue | Practice | Expected Results |
|---|---|---|
| "Peeper" planting Material | Banana seedlings developed from "peepers" taken from the production field and grown for 3 months following nursery practices. | Reduced cost of planting materials |
| | Peepers should reach approximately 40 cm in height, with 4 to 5 functional green leaves present to be ready for transplanting. | Income from seedlings |
| Land preparation – New Technology | Deep ploughing using a Disk Plough of 60 cm diameter or mouldboard plough | Reduced loss of water, nutrients and healthy plants consequently reduces the cost of production. |
| | Application of compost | |
| | Deep ploughing using a Disk Plough of 60 cm diameter or mouldboard plough(perpendicular to first ploughing) | |
| | Disk plough of 40 cm diameter or harrowing (two perpendicular passes) | |
| | Micro levelling to facilitate drainage works | |
| Mini-sprinkler irrigation systems | Computer-controlled heads for water application scheduling supported by fertility sensors and soil moisture sensors | Reduction of the quantity of water required, reduction of the quantity of fertilizer required, reduction of the quantity of pesticides required, consequently, the reduced cost of production due to the increase in efficiency of liquid application. |
| | Precision fertigation with liquid organic compounds | |
| | Precision application of liquid pesticides | |
| | Anti-clogging flushing components | |
| Flood prevention and drainage - field techniques– New | Site levelling using laser levelling machinery, quick water evacuation ditches, Surface drainage techniques | Reduction of waterlogging and consequent crop losses. Decreased cost of production |

| | | |
|---|---|---|
| Technology | (removal of wet spots) | |
| Precision planting | Construction-type twine to demarcate planting rows, planting templates with plant spacing measurements | Increased plant density, Increased yield and harvest, Increased income |
| Double row planting system– New Technology | Bananas are planted in two double rows 1 m apart. | |
| | The spacing for bananas within a double row is 1.75 m | |
| | An alley, 4 m wide, separates the double Rows. | |
| Multiple cropping | | Increased cropping intensity, Increased income |
| Weeding | | Mechanical weeding prevents environmental problems. |
| Precision Fertilization | Fertigation with organic liquid fertilizers supplemented with fertilization and/or fertigation with chemical fertilizers | Reduced quantity of fertilizer, reduced cost of fertilizer. |
| IPM | Pest population and pest damage assessment surveys to evaluate pest and disease intensity/quantity factors for damage prevention and to determine pest population threshold status for rational application of pesticides. | Reduced quantity of pesticide required due to reduction of waste of pesticides Reduced cost of pest control Contribution to environmental protection |
| | Prevention and management of Fusarium wilt (Panama disease) | |
| | Control of Sigatoka disease and other pre and post-harvest diseases | |
| Labelling for precision agriculture | Production area blocks and tree tagging labelling | Reduction of waste of products, Reduction of cost of production, Reduction of waste of inputs (material and time), Contribution to environmental protection |

### 7.4.1 Adoption of the Quality Enhancing Technology- Rajangana Ambul Cluster

Table 31 presents information on the adoption of the quality enhancing technology by the farmers from the Rajangana Ambul banana cluster. All of the interviewed farmers (100%) adopt bunch clearing after bagging and tagging with coloured ribbons. Propping is not practised as farmers think that Ambul banana stems are strong enough to bear bunches. According to farmers, they have been able to improve the appearance and quality of Ambul banana by adopting these practices of quality enhancing technologies. Bunch clearing practice is important for producing quality banana as remaining flower buds can cause fungal attacks. According to Table 31 which presents farmers' responses to the benefits of bunch clearing practice, farmers agree that bunch clearing is useful for producing quality banana. It shows that most of the interviewed farmers accept and adopt these practices of quality enhancing technology.

Out of the interviewed farmers, 100% (5) practice de-handing with fish line and de-latexing as they sell their product to the packing centre. No farmer is reported to have adopted postharvest technology.

Table 31: Practices of quality enhancing technology introduced by the ASMP for Ambul banana to Rajanagana cluster

| Introduced Practices | | % of the adopted farmers | Remarks |
|---|---|---|---|
| Bunch clearing before bagging | Removing leaves that can damage bunch and bending or removal of placenta leaf | 60% (3) | 40% |
| Bagging with plastic bags | Premature bagging when the bunch is just emerging and the centre flower bud points downward | 100% (5) | |
| Bunch clearing after bagging | De-leafing, de-flowering, De-handing, disbudding | 100% (5) | |
| Tagging of the banana bunch with coloured plastic ribbons | Every week a different coloured ribbon is applied when the lower hands are parallel to the ground. Eight colours are used | 100% (5) | |
| Propping and guying | The banana bunch is propped with wooden poles tied with rope or plastic | 0 | Propping is not practiced as the stem is strong enough to bear bunches |
| Harvesting by de-handing at the Mat | Bunches for de-handing in the field are selected based on age (ribbon colour) and caliper grade to protect the quality, prevent ripening and turnings during transport and extend shelf life | 100% (5) | |
| | Hands are removed from the bunch using a fish line (100 test) that cuts and seals the crown properly with no additional trimming required | 100% (5) | |
| De-latexing in the field | Removed hands from the harvested bunch are placed on banana leaves for de-latexing for at least one hour | 100% (5) | |
| Transport to packing centre | Packing the de-latexed hands into 20-kg plastic trays lined with foam. One bunch, one crate | 100% (5) | |
| | Colour ribbon tied securely to crate to allow for inventory management at packing centre | | |
| Postharvest technology | Field heat removal Line packing Cold chain management Integration of export protocols into standard SOP's | 0 | No one adopts as they do not have such a facility |

Table 32: Farmers' response to the benefits of bunch clearing practice

| Technological Practice | Benefits of the practice | Farmers response |
|---|---|---|
| Bunch clearing before bagging and plastic bags | Protection of fruits from sunburn, hot wind and dust | 40% (2) |
| | Having an attractive colour – therefore, a better market price | 40% (2) |
| | Yield increases of 15% - 20% | 20% (1) |
| | Preventing main stalk rot | 20% (1) |
| | Avoiding fingertip disease due to removal of infection by saprophyte fungi | 20% (1) |
| | Appearance is good and buyers buy | 20% (1) |
| Bunch clearing after bagging | Reduction of fungal damage | 60% (3) |
| | Reduction of insect damage | 60% (3) |
| | Reduction of abrasion injury on fruit skin | 60% (3) |
| | Quality banana (appearance is good) | 60% (3) |

### 7.4.2 Adoption of the New Technology - the Rajangana Ambul Cluster

Table 33 indicates the practices of the new technology package the ASMP introduced for banana fruit crops and the percentages of the interviewed farmers adopting these practices. As per the table, some of the introduced practices have been adopted.

The first practice of the table is related to the planting material of Ambul banana, banana seedlings developed from "peepers" taken from the production field and grown for 3 months in a nursery. All the interviewed farmers have taken from their own fields as they are Ambul banana growers.

As shown in Table 33, deep ploughing is practised twice using a disc plough, adding compost, harrowing and micro levelling. All the interviewed farmers (100%) adopted 1st and second deep ploughing, harrowing, levelling and composting. Deep ploughing is necessary to banana well.

A mini sprinkler irrigation system has been provided free to these farmers too. Out of the interviewed farmers from the Rajangana Ambul cluster, 20% irrigate Ambul banana cultivation with this sprinkler irrigation system and other farmers (80%) practice flood irrigation diverting water from irrigation canals of Rajangana.

All the farmers (100%) practice precision planting and double row planting system which gives a higher harvest and income. Only 40% of the interviewed farmers have grown an intercrop but none has been successful.

Some of the interviewed farmers (40%) have practised fertigation for 6-month and 9-month period. None of adopting any pest or disease control method based on IPM.

Bagging banana bunches is another practice the ASMP introduced. Initially, the ASMP provided bags. All farmers practice bagging banana bunches as it prevents fruits from physical damage and pest attacks. Further, bagging causes the production of quality banana which can be sold at a higher price.

Table 33: Farmers adopting practices of new technology introduced by the ASMP for Ambul banana in Rajanagana cluster

| Introduced Practices | | % of the adopted farmers | Remarks |
|---|---|---|---|
| "Peeper" planting material | Banana seedlings developed from "peepers" taken from the production field and grown for 3 months following nursery practices | 100% (5) | Peepers are developed from their production field |
| | Peepers should reach approximately 40 cm in height, with 4 to 5 functional green leaves present to be ready for transplanting | | |
| | Tissue culture plants provided by ASMP | | |
| Land preparation | Deep ploughing using mouldboard plough | 100% (5) | |
| | Application of compost | 100% (5) | |
| | Deep ploughing again using a mouldboard plough (perpendicular to first ploughing) | 100% (5) | |
| | Disking or harrowing (two perpendicular passes) | 100% (5) | |
| | Micro levelling to facilitate drainage works (manual) with a backhoe | 100% (5) | 20% farmers did manually and others used a backhoe |
| Mini-sprinkler irrigation systems | Precision fertigation with liquid organic Compounds | 20% (1) | Most of the farmers practice flood irrigation as they can divert water from the canal of Rajangana reservoir. |
| | Anti-clogging flushing components | 20% (1) | |
| Flood prevention and drainage field techniques | Site levelling using laser levelling, machinery, quick water evacuation ditches, surface drainage technique machinery, quick water evacuation ditches, surface drainage techniques (removal of wet spots) | 0 | Do not use laser levelling and use a machine or a backhoe to level and prepare drains |
| Precision planting | Construction type twine to demarcate planting rows, planting templates with plant spacing measurements | 100% (5) | |

| | | | |
|---|---|---|---|
| Double row planting system | Bananas are planted in two double rows 1m apart | 100% (5) | |
| | The spacing for bananas within a double row is 1.75 m | 100% (5) | |
| | An alley, 4 m wide, separates the double Rows | 100% (5) | |
| Multiple cropping | Intercrop cultivation | 40% (40) | 40% have been cultivated. Not successful. |
| Precision fertilization | Fertigation with organic liquid fertilisers supplemented with fertilization and/or fertigation with chemical fertilisers | 40% (2) | 20% of the interviewed have practiced fertigation for the first 6 months and another 20% have practiced it for 9 months. 60% of the interviewed have not practiced it at all. These farmers think that fertilizers applied through fertigation are not sufficient. |
| Pest and disease control based on IPM practices and modern spray techniques | Pest population and pest damage surveys to assess pest threshold status for the application of pesticides. Pest population and pest damage surveys to assess pest threshold status for the application of pesticides | 0 | None of the interviewed reported that they are practicing IPM-based pest control methods |
| | Prevention and management of Fusarium wilt (Panama disease) fungicide mixtures | 0 | |
| | Control of Sigatoka disease and other pre and post-harvest diseases | | |
| Labelling/ bagging for precision agriculture practices | Bagging and tree tagging | 100% (5) | All farmers practice bagging |

### 7.4.3 The New Technology Packages for Ambul Banana Cultivation

The quality management practices introduced by the ASMP for Cavendish banana are equivalent to the Ambul banana. The only difference is the use of peeper planting material for the Ambul banana as described in Table 34, below.

When compared to the DOA recommendations and farmers' practices, Ambul banana did not show any difference to Cavendish banana.

Table 34: Data relevant to quality-enhancing technologies for Ambul Banana

| Main Technology | Practice | Data required |
|---|---|---|
| "Peeper" planting Material | Banana seedlings developed from "peepers" taken from the production field and grown for 3 months following nursery practices. | Reduced cost of planting materials |
| | Peepers should reach approximately 40 cm in height, with 4 to 5 functional green leaves present to be ready for transplanting. | Income from seedlings |

### 7.4.4 Practices of the existing Technology of Ambul Banana Cultivation

Farmers who are cultivating Ambul banana in Rajangana area prepare the land with rotary and manual levelling. They irrigate the crop by flooding the field by diverting water from a canal of Rajangana reservoir or pumping water from a canal of the Rajanagana reservoir.
Plants are mostly taken from their own plant base or from other banana farmers. Existing farmers do not plant in the double-row system and the number of plants cultivated is 400 for 0.5 acre. They apply fertilizer manually and use pesticides and weedicides when required. These farmers do not adopt de-handing and bunch clearing and bunches are sold when maturity is enough to harvest.

### 7.4.5 Utilization of Input

Table 35 shows the average amount of some of the inputs currently utilized for growing banana in 0.5 ac per year using the new technology and existing technology, amounts of all input items utilized for cultivating Ambul banana with the new technology are greater than those utilized for cultivating Ambul banana with the existing technology.

According to the technology package introduced by the ASMP, banana should be irrigated with a mini sprinkler irrigation system whereas the existing farmers practice flood irrigation. Introducing sprinkler irrigation is expected to increase irrigation efficiency and reduce the volume of water used for irrigation and the cost of irrigation. As per the information given in Table 35, the volume of water used to irrigate Ambul banana in Rajanagana with the new technology is slightly higher than that with the existing technology. The average annual volume of water used to irrigate 0.5 acre with the new technology is 2,612,533 litres and that volume with the existing technology is 2,400,000 litres. This deviation from the expected result is that farmers of the Rajangana cluster use water from ago wells, Rajangana reservoir or Kala Oya. Farmers tend to practice flood irrigation even with new technology as they can divert water from the canals of Rajanagana reservoir without a cost. Some farmers adopt both sprinkler irrigation and flood irrigation because they think that sprinkler irrigation does not supply the volume of water required for plants. Therefore, the volume of water irrigated with new technology, the cost of energy incurred for irrigation and the cost of labour used for irrigation are greater than those with the existing technology.

The cost of energy incurred in irrigating banana cultivation by existing farmers is zero as they divert water (flood irrigation) from irrigation canals of Rajanagana reservoir. Energy costs can be reduced to zero with the operation of solar panels which had not been provided within the first two years.

Thus, the average annual labour used for irrigating 0.5 ac of Ambul banana cultivation under the sprinkler irrigation system is 25 man-days and that under the existing technology is 16. The cost of labour with the new technology is Rs. 75,250/= and that with the existing technology is Rs. 48,000/=.

As depicted by Table 35, the quantity of fertilizer used under the improved new technology package is 885 kg per 0.5 acre for a year and fertilizer quantity under existing technology is 270 kg per 0.5 acre for a year. The average annual fertilizer cost under the new technology and the existing technology for 0.5 ac of Ambul banana cultivation is Rs. 172,612/= and Rs. 50,428/= respectively. Farmers do not follow advice given by the ASMP regarding fertilizer application and they think that fertilizer applied through fertigation is not sufficient for crop growth and it is necessary to apply fertilizer to each plant by hand. When fertigating, fertilizer dissolved in water is spread over the field and not properly applied to each plant. The manual application of fertilizer incurs a labour cost. The average annual labour used to apply fertilizer for 0.5 ac of Ambul banana cultivation under the new improved technology and the existing technology is 8 man-days and 2.5 man-days, respectively while labour cost regarding the former is Rs. 25,000/= and the latter is Rs. 7,555.56/=. It seems that the amount of inputs with the new technology package is greater than the existing technology used in Ambul banana cultivation. According to farmers, investment costs and quantities of inputs are used largely compared to the existing technology. Precision fertilizer application can increase the efficiency of fertilizer application, cost of production and environmental problems caused by excess quantities of fertilizer. Precision fertilizer application requires soil testing and foliage analysis which are not easily accessible to farmers due to awareness problems.

Table 35: Average amount of inputs currently utilized for growing Ambul banana in 0.5 acre per year using the new technology and existing technology

| Item | Unit | New Technology | Existing Technology |
|---|---|---|---|
| Average volume of water irrigated per 0.5 acre per year | litre | 2,612,533 | 2,400,000 |
| Average amount of labour utilized for irrigation per 0.5 acre per year | Man day | 25 | 16 |
| Average annual energy cost for irrigation per 0.5 acre | Rs. | 39,256 | Nill |
| Average annual labour cost for irrigation per 0.5 acre | Rs. | 75,250 | 48,000 |
| Average quantity of fertilizer utilized per 0.5 acre per year | Kg | 885.17 | 270.37 |
| Average amount of labour utilized for applying fertilizer per 0.5 acre per year | Man day | 8 | 2.5 |
| Average annual fertilizer cost per 0.5 acre | Rs. | 172,612.50 | 50,428.57 |
| Average annual labour cost for applying fertilizer per 0.5 acre | Rs. | 25,000 | 7,555.56 |

### 7.4.6 Ambul banana production with the New Improved Technology and the Existing Technology

According to farmers from Rajanagana, the crop can be mostly harvested at the end of the first year or in the second year although Ambul banana takes about 9 months after planting to reach the flowering stage and another three months for reaching to maturity enough for harvesting. Average weight of a bunch of Ambul banana is 12 to 15 kg. Table 36 presents changes in average annual production and average revenue of Ambul banana per 0.5 ac over six years with the new improved technology and existing technology. Rajangana Ambul banana cluster has been functioning for two years and farmers can predict future harvest according to clump management (Box - 03).

**Box - 03**
**Yield Forecasting of Ambul Banana**

Farmers from Rajangana Ambul banana cluster let to grow three plants in a clump and others are removed or chopped. They maintain clumps according to the new improved technology. According to the interviewed farmers, each plant of a clump is maintained at a 4-month time gap. Therefore, each clump always bears a bunch. When one bunch is harvested, another plant of a clump bears a bunch.

Each farmer cultivates 450 Ambul banana plants in 0.5 acre due to the double row planting method. Therefore, 1st harvest is 450 bunches at the end of the first year or in the 2nd year after planting. Almost every farmer reaps the first harvest in the second year within. Thereafter, harvest depends on way of managing clumps and according to farmers, they can harvest every week.

In addition, farmers from the Rajangana Ambul banana cluster sell plants (suckers) at Rs. 50/= per sucker and earn an additional income. According to farmers, they can remove about 50 peepers (suckers) from a clump per week and 200 suckers per month. Then, 2400 suckers can be produced per year with the new technology package where number of plants in 0.5 acre is 450 (double row system). However, considering market demand and other uncertainties, it is assumed here that a farmer sells or produces 2000 suckers per year. In contrast, farmers say that they cultivate between 350 - 400 plants in 0.5 ac with the existing technology. It is assumed that farmers can sell about 800 suckers from 0.5 ac per year with the existing technology and cultural practices they adopt.

Effects of all practices of both the new improved and existing technology packages can be observed as fruit production. Therefore, Ambul banana production corresponding to these two technology packages can be taken as an indicator to evaluate the superiority of the technology packages.

As shown in Table 36, the average annual production of Ambul banana per 0.5 acre with the practices of the improved new technology is higher than that with the existing technological practices over a year period. Double row planting pattern of the new improved technology which increases Ambul banana plant density is directly linked with production increase. Plant density with the new improved technology is 450 plants per 0.5 acre while that is 375 plants per 0.5 acre with the existing technology.

Average annual Ambul banana production with the new improved technology package increases from 5,012 kg per 0.5 acre in the second year to 9,604 kg per 0.5 acre at the third year. After the third year, harvest becomes constant in the fourth, fifth and sixth years. Ambul banana production with the existing technology starts in the second year and is 5,500 kg per 0.5 acre per year over the next four-year period.

Generally, damage to Ambul banana is negligible. The average annual income from Ambul banana with the new improved technology varies with market price and the price reported by the interviewed farmers varies from Rs. 50/= to Rs. 150/= per kg. Therefore, the reported average value of the harvest is Rs. 479,640/= in the second year and Rs. 1,272,200/= in the third year and the remaining years. The average value of Ambul banana production with the existing technology is Rs. 220,000/= per year.

Labour and labour costs for harvesting with the new improved technology is higher than those under the existing technology because the production of Ambul banana with the new technology is greater than that with the existing technology. The average number of labour used for harvesting Ambul banana with the new technology is 7 man-days in the first year and then, 10.4 man-days for the remaining years. The average amount of labour for harvesting with the existing technology is 1.8 man-days for each year. The yield of Ambul banana with the new technology is greater than that with the existing technology. Therefore, amount of labour used for harvesting is also greater than that with the existing technology.

In addition to banana bunches, by selling plants produced in 0.5 acre of Ambul banana cultivation, a farmer can earn Rs. 100,000/= per year with the new technology and it is Rs. 4000/= per year with the existing technology. With the new technology, double row planting pattern and sufficient fertilizer application can produce more plants than with the existing technology.

Table 36: Changes in average annual production and average annual revenue of Ambul banana per 0.5 ac over five years with the new improved technology and existing technology

| Description | New technology | | | | | | Existing technology | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | | 1 | 2 | 3 | 4 | 5 | 6 |
| Average harvest of Ambul banana (kg) | | 5012 | 9604 | 9604 | 9604 | 9604 | | | 5,500 | 5,500 | 5,500 | 5,500 | 5,500 |
| Average value of (gross revenue) of Ambul banana (kg) | | 479,640 | 1,272,200 | 1,272,200 | 1,272,200 | 1,272,200 | | | 220,000 | 220,000 | 220,000 | 220,000 | 220,000 |
| Average amount of labour used to harvest Ambul (md) | | 7.35 | 10.4 | 10.4 | 10.4 | 10.4 | | | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| Average labour cost for harvesting Ambul (Rs.) | | 22,050 | 31,200 | 31,200 | 31,200 | 31,200 | | | 5,500 | 5,500 | 5,500 | 5,500 | 5,500 |
| Number of Ambul banana plants produced from 0.5 acre for selling | | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | | | 800 | 800 | 800 | 800 | 800 |
| Gross revenue from selling banana plants at price of Rs. 50/= | | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | | | 4000 | 4000 | 4000 | 4000 | 4000 |
| Total gross revenue from Ambul banana cultivation of 0.5 acre | | 579,640 | 1,372,200 | 1,372,200 | 1,372,200 | 1,372,200 | | | 224,000 | 224,000 | 224,000 | 224,000 | 224,000 |

### 7.4.7 Cost of Production of Ambul banana

The cost of production of Ambul banana with the new improved technology and the existing technology can be used to compare the efficiency of these two technologies. The cost of production is the cost incurred in producing a kilo of Ambul banana. Table 37 and Table 38 present changes in harvest, cost of cultivation and cost of production of Ambul banana over five years with the new improved technology and those with the existing technology, respectively.

According to information from Table 37 and Table 38, the cost of production of Ambul banana has drastically decreased from the second year to the third year in both cases. From third year, cost of production is constant in both cases.

The cost of production of Ambul banana with the new improved technology is Rs. 235/= per kilo in the second year and thereafter, it is Rs. 48/= per kilo in the third year and onwards. The cost of production with the existing technology is Rs. 42/= per kilo in the second year and Rs. 16/= per kilo in the third year and onwards. Except for the first year, the cost of production with the existing technology lower than that with the new improved technology. Cost of cultivation with the new improved technology is larger than that with the existing technology. Although Ambul banana harvest with the new improved technology is larger than that with the existing technology, difference of harvest is lower than difference of cost of cultivation between two cases. Therefore, farmers who adopt the existing technology have a breakeven at a low market price compared to those who adopt the new improved technology. Farmers adopted the new improved technology as the ASMP assisted by bearing a part of the initial investment of each member farmer (I have considered that a farmer bears all costs if the cost the ASMP spent is considered).

Table 37: Changes in the cost of production of Ambul banana per 0.5 ac per year over five years with the new improved technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Average harvest of Ambul banana(kg) | 0 | 5,012 | 9,604 | 9,604 | 9,604 | 9,604 |
| Average cost of cultivation of Ambul banana (Rs.) * | 727,501 | 449,395 | 465,988 | 465,988 | 465,988 | 465,988 |
| Cost of production (Rs/kg) * | 0 | 235 | 48 | 48 | 48 | 48 |

*Note: All costs are imputed costs as the opportunity cost of family labour is included.

Table 38: Changes in the cost of production of Ambul banana production per 0.5 ac per year over five years with the existing technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Average harvest of Ambul banana (kg) | 0 | 5,500 | 5,500 | 5,500 | 5,500 | 5,500 |
| Average cost of cultivation of Ambul banana (Rs.) * | 141,410 | 90,593 | 90,593 | 90,593 | 90,593 | 90,593 |
| Cost of production (Rs. per | 0 | 42 | 16 | 16 | 16 | 16 |

| kg) * | | | | | | | |
|---|---|---|---|---|---|---|---|

*Note: All costs are imputed costs as the opportunity cost of family labour is included.

### 7.4.8 Financial Analysis

Financial analysis is conducted to check how the project is benefiting beneficiaries. The following conditions are considered in conducting the financial analysis.

1. The ASMP has provided free land preparation, a mini sprinkler system, planting material and a water pump. These can be considered as subsidies to beneficiaries to motivate them. Generally, subsidies are considered as income in financial analysis. Here, the value of these items is considered a cost to the beneficiaries because the analysis is focused on checking the superiority of technologies and the cost incurred in adopting these technologies should be covered by the project.

2. All taxes such as VAT, PAL, SSL and duties of the imports are included in the market price of these commodities.

3. Inflation of input prices and output prices is not considered. It is assumed that the effect of inflation may be cancelled out

4. Both inputs and Ambul banana production are valued using existing market prices.

5. Ambul banana is harvested from the second year and analysis is done for six years.

6. The discount rate used for calculating NPV, Present Values of cost and benefit is the average fixed deposit interest rate (08%).

Table 39 presents FIRR, FNPV and Benefit Cost Ratio relevant to 0.5 ac of Ambul banana cultivation with the new improved technology and the existing technology. According to Table 39, FIRR for an investment in Ambul banana cultivation with the new improved technology is 72% and that is 91% with the existing technology. These FIRR values indicate that 0.5 acre of Ambul banana cultivation with the new technology generates benefits at a lower rate (72%) to a beneficiary than that with the existing technology (91%). The present value (at 8%) of net worth generated from 0.5 ac of Ambul banana cultivation with the new improvement is Rs. 2.0113 million per annum while the existing technology is Rs. 0.3622 million per annum. The benefit-cost ratio regarding the new technology is 200% and that for the existing technology is 178%. According to these value criteria, Ambul banana farmers do not gain advantages by adopting the new improved technology compared to the existing technology.

Table 39: IRR, NPV and B/C for NT and ET relevant to 0.5 ac of Ambul banana

| Criterion | NT | ET |
|---|---|---|
| FIRR | 72% | 91% |
| FNPV (Rs. million) - at bank fixed deposit rate, 8% | 2.0113 | 0.3622 |
| B/C | 200% | 178% |

### 7.4.9 Issues Related to Ambul Banana Cultivation

According to the interviewed farmers, there is no issue except the market price which is not sufficient to cover the cost of production. If there are ways of reducing the cost of production with the new improved technology such as solar power generation which can reduce irrigation costs, the new technology can be made more useful.

Another way of reducing cost of production is application of required quantities of fertilizer through implementing precision fertilizer application and enhancement of farmer awareness about correct quantities of fertilizer. The cost of fertilizer application is more than 40% of the total cost of Ambul banana cultivation. The percentage of the cost of fertilizing of total production cost with the new improved technology and the existing technology is 40% and 59% respectively. Precision fertilizer application requires foliage analysis and soil testing before applying fertilizer which is a costly and technical task. Therefore, the government should provide facilities so that any farmer can have advice for fertilization at an affordable cost.

### 7.4.10 Conclusions

Both the new technology introduced by the ASMP and the existing technology with regard to Ambul banana cultivation are financially viable. The new technology can increase yield compared to the existing technology but the cost of production of Ambul banana with the new technology is greater than that with existing technology. Farmers who adopt the new technology cannot exist when the market price is less than Rs. 48/= per kilo. However, farmers who adopt the existing technology can exist when the market price is less than Rs. 48/= per kilo.

### 7.4.11 Cash Flows of Financial Analysis of Ambul banana Cultivation

Table 40: Cash flows of the financial analysis of 0.5 acre of Ambul banana cultivation with new improved technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Land preparation | 68,550 | | | | | |
| Cost of developing plants from peepers for 0.5 acres | 25,475 | | | | | |
| Labour cost for planting banana in 0.5 acre | 9,600 | | | | | |
| Mini sprinkler irrigation system per 0.5 acre and water pump | 200,000 | | | | | |
| Cost for irrigating 0.5 acre of Ambul banana | 119,218 | 110,794 | 110,794 | 110,794 | 110,794 | 110,794 |
| Cost for applying fertilizer | 194,383 | 196,856 | 200,599 | 200,599 | 200,599 | 200,599 |
| Cost for weed control | 58,980 | 53,538 | 53,538 | 53,538 | 53,538 | 53,538 |
| Cost for bagging and tagging Ambul banana | 31,296 | 46,158 | 49,858 | 49,858 | 49,858 | 49,858 |
| Cos for harvesting | - | 22,050 | 31,200 | 31,200 | 31,200 | 31200 |
| Depreciation of sprinkler system and pump at 10% | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 |
| **Cash outflow** | **727,502** | **449,396** | **465,988** | **465,988** | **465,988** | **465,988** |
| **Cash inflow (Revenue from Ambul banana)** | - | 579,640 | 1,372,200 | 1,372,200 | 1,372,200 | 1,372,200 |
| **Net cash flow** | **(727,502)** | **130,244** | **906,212** | **906,212** | **906,212** | **906,212** |

Table 41: Cash flows of the financial analysis of 0.5 acre of Ambul banana cultivation with the existing technology

| Year | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Land preparation | 9,500 | | | | | |
| Planting material (Tissue culture plant) | 25,000 | | | | | |
| Labour cost for planting | 17,250 | | | | | |
| Cost for irrigating Ambul banana | 12,667 | 12,667 | 12,667 | 12,667 | 12,667 | 12,667 |
| Cost for applying fertilizer | 61,029 | 56,462 | 56,462 | 56,462 | 56,462 | 56,462 |
| Cost for weed control | 15,965 | 15,965 | 15,965 | 15,965 | 15,965 | 15,965 |
| Cos for harvesting | - | 5,500 | 5,500 | 5,500 | 5,500 | 5,500 |
| **Cash outflow** | **141,410** | **90,594** | **90,594** | **90,594** | **90,594** | **90,594** |
| **Cash inflow (Revenue from Ambul banana)** | - | 224,000 | 224,000 | 224,000 | 224,000 | 224,000 |
| **Net cash flow** | **(141,410)** | **133,406** | **133,406** | **133,406** | **133,406** | **133,406** |

## 7.5 Studies on Other Crops Assigned by ASMP

### 7.5.1 Pomegranate Cluster

The ASMP project has introduced a new technology package for pomegranate cultivation in Kalmunai West in Mullaitivu district and Kalawanchikudy in Batticaloa district. The new technology includes an espalier trellis system, mini sprinkler irrigation and fertigation. Farmers from two pomegranate clusters in two districts have not cultivated pomegranate before, and the ASMP has introduced it to them first.

If the pomegranate cluster of Mullaitivu district is considered, these farmers have not harvested yet and pomegranate cultivations have just started fruit setting. With regard to the pomegranate cluster in Batticaloa district, some of the farmers have harvested once, and others have not yet harvested. Further, these farmers do not have experiences of pomegranate cultivation and predicting how the espalier system contributes to increasing pomegranate production. Therefore, it seems that it is too early to check the superiority of the new technology package introduced by the ASMP against the existing technology and pomegranate is dropped from this assignment.

### 7.5.2 Potato/Red Onion Cluster

According to farmers from Jaffna, they have not been cultivating potato for about 5 years due to the unavailability of potato seeds. The ASMP project provided potato seeds for a season to the selected farmers two years ago. Thereafter, no one has cultivated potato due to the unavailability of potato seeds.

### 7.5.3 Okra/Brinjal Cluster

Although this vegetable cluster has been included in this assignment, data collection could not be carried out due to a flood situation caused by a cyclone that happened during the field visits.

# 8. Policy issues

## 8.1 Identification of Policy and Regulatory Gaps

Identification of policy and regulatory gaps were addressed to promote new technology packages beyond the ASMP crop clusters.

Identification of policy gaps or requirements in changing existing policy to facilitate the promotion of new technology packages. It is necessary to identify barriers or issues faced by farmers when engaging in agricultural activities. These barriers may be related to production and marketing. Then, it was necessary to identify whether these barriers could be removed or overcome by changing existing policies or introducing new policies.

Table 42: List of Policy Issues

| Item | Barrier/ issues | Related policy |
|---|---|---|
| Production | Land availability and ownership issues | Land policy related to agriculture and requirement of land ownership |
| | Availability of imported | Policy related to importation of agricultural inputs |

| | | |
|---|---|---|
| | inputs: fertilizer, agrochemicals, seed | and quarantine policy |
| | Labour availability | Labour policy related to agriculture |
| | Accessibility to water sources or irrigation issues | Irrigation policy or relevant regulations |
| Marketing | Facilities to reach marketplaces | Policy related to marketing and trade |
| | Infrastructure facilities | Policy related to rural development |
| | Barriers to having competitive market prices at local markets | Existing marketing policy and regulations |
| | Possibility to export and hindrances for exporting | Trade policy |

## 8.2 Observations on Policy Interventions Required

1. The superiority of the new technology (NT) over the existing technology (ET) depends on the adaptability, convenience of practising the recommendations, relative economic gains, and marketability of the product.

   Adaptability depends on the simpleness of the technology, affordability and the relatively enhanced income from the NT over the ET. The convenience of practising the recommendations depends on the ease of adopting, greater accessibility to methods and material used and less time spent on adopting. Economic gains depend on the quantity and quality of the product, which are effects of the total package of practices of the NT. The total income from the adoption of NT depends on the yield (kg) per tree and unit of land (ac/ha) while the enhanced quality will enable the product to receive a better marketable price.

   Most components of the NT are well-defined and standardized for the farmers to practice without much inconvenience by the crop manuals prepared by the PMU. For example, in the NT, land preparation is recommended as a uniform practice for all the crops that had been considered whereas in ET there is no such well-defined process for land preparation. Similarly, procedures are defined for planting material selection, planting, crop management, fertilizing, irrigation, pest and disease management, product quality management and harvesting. Also, the manuals consist of post-harvest technologies as well.

   **Policy interventions:** Accept the new technologies as the future implementation requirements, grant support and acquire responsibility for the implementation of new technologies as promoted by the ASMP and replace existing technologies gradually through a dedicated service provision mechanism.

   **Policy interventions:** General extension service is unable to engage in value addition and value chain development for a few specific crops having export potential because they have to cater for the production demands of a large number of crops. Therefore, it is required to establish dedicated private sector Service Providers for each crop and establish dedicated institutes to promote, conduct research, introduce new technologies, monitor production and export processes etc. as the government has done for the Cinnamon sector.

2. In the Sri Lankan context, it is apparent that some components contained in the new technology are difficult to practice owing to the cost of such operations and the cost of material required to implement the technologies. Especially in the case of fruit planting, land preparation with the disc plough in 02 different directions followed by harrowing in 2 directions would be seemingly too costly for an average farmer, instead of loosening the soil of pits for planting fruit plants with a backhoe in ET. In the case of the Espalier System, the cost of steel tubes and wires may be unaffordable for an ordinary farmer. Nonetheless, the final effect of both these technologies is deemed to show an enhanced yield compared to the existing technology. Therefore, the extension of such technologies to a larger farming population may require financial support for the farmers while steps need to be taken to bring about attitudinal changes towards adopting such technologies.

   **Policy interventions:** Grant subsidies and credit on low interest with extended pay-back periods are recommended to promote the new technologies and ensure the availability of such material required at duty-free prices for the prospective farmers and PUCs.

3. As a matter of demonstrating the new technologies, the Agricultural Technology Development Parks (ATDPs) have played their intended role well. The total technological packages of several crops have been introduced to a large number of farmers in 07 Districts of 05 provinces. To reap the benefits of ATDPs, it is best to organize a group of farmers adjoining each other or close by so that the effect of such a large-scale demonstration will have a visual impact. With the current selection of farmers, the sites are somewhat scattered which is likely to dilute the visual impact of demonstrations. Also, it will diminish the cohesive effects and cumulative advantages of being together, such as the delivery of inputs and the arrangement of markets.

   However, from a different angle, such a scatter of sites may also be advantageous since it would expose a greater number of farmers to the new technologies in a wider geographic area so that the adoption and expansion phase would occur faster. But in terms of machinery use, input supply, product management, processing and marketing better advantage would have been taken, if at least a group of farmers neighbouring to each other, were considered for the program. The demonstration indeed takes place in only a part of the land of each farmer, such as ½ ac, while the rest of the land would be used for another crop. But once the farmers acquire the technologies and start appreciating them as viable and feasible, they will expand the crop and the technologies to the entire land, which will give a spin-off effect for all other farmers to expand the technologies to all their lands. This will give a view of a plantation-style cultivation of a single crop in one area which can be facilitated by a private sector unified service provider or an organization managed by the farmers. Also, such a large plantation-style crop cultivation would facilitate taking steps as a group of farmers to reduce wild animal damage by deterring them.

   **Policy interventions:** The concept of ATDP needs to be accepted as a group approach to promote fruit crops /seasonal crop cultivation similar to implementing plantations of mono crops so that services, input and markets can be arranged easily.

4. The Project has initiated the establishment of Public Unlisted Companies (PUCs) consisting of farmer shareholders to mainly deal with the marketing aspects of the products of the ASMP intervention groups. The effects of the interventions of the PUCs are yet to be shown. PUCs have been active in Rajangana and Sevanagala Banana plantations and are reported to be engaged in providing banana for exports and supermarkets respectively but with mixed results. However, the potential of the market interventions by PUCs will depend on the price of the product in the market, accessibility to the markets, and the cost of production. If the margin between the cost of production

and the wholesale market price is low, the profit margin may not be advantageous for the PUCs to be involved in the value chain. If the market is inaccessible due to distance, restrictions and malpractices, no longer the PUCs can compete with the private traders.

**Policy interventions:** Further studies need to be conducted on the efficacy and implementation ability of the PUCs.

5. There is a need to critically analyse the ultimate goal of PUCs, to be engaged in exports. The ASMP has introduced technologies to improve the quality of fruit products to be commensurate with the demands of international markets, such as bagging, harvesting at the best stage etc. However, the question is whether the farmers have acquired the desired quality consciousness that will match the production of high-quality fruit products for an international market. Also, the question is whether the farmer can produce such high-quality fruits for a low price to match the prices in the international markets, according to the cost of input and services available within the country. This may need further attention and focus if needed continuation. As the global prices behave, there is no alternative but to reduce the price of exported products offered to the international market by the local exporter to stay competitive in such markets. The FOB price of the exporter at the exported port will consist of shipping charges, insurance, loading charges, bank charges, local transport costs, storage and processing costs and the wholesale price they offer for the intermediary or the farmer. If the farmer as well as PUCs expect a very high price for the product, the exporter will have to either lose or slump on the profit he expects. Therefore, there is a need to educate and sensitize the farmers and PUCs on the costs of items and operations in the value chain, to build the "business bridge" between the producer and the exporter.

   **Policy interventions:** More studies need to be conducted on the taxes and charges on exporting and export markets in order to support the exporters to maintain competitiveness in the international markets. Also, government officials should consider the private sector exporters as giving a service for the export markets and helping in the sustenance of the local farmers but not fleecing them as widely considered.

6. Sri Lanka has varied experiences regarding the establishment and operations of farmer institutions during the last several decades. The irrigation sector initiated farmer organizations for water sharing which sustained up to now with mixed outcomes. However, since the farmers understand the benefits of sharing scarce resources of irrigation water, the FOs have remained intact up to now. In the late 1990s, the government experimented with establishing farmer companies with the experiences learnt from the pioneering Hurulu Wewa farmer company (HWFC). HWFC was primarily involved in the marketing of soya with cultivation, purchasing and supply of the seed to the Thriposha. This exercise failed within a short time as the farmers could not understand the intricacies of marketing. The farmer companies initiated in the late 1990s by the Ministry of Irrigation and Mahaweli were involved in the operation and maintenance of irrigation structures and schedules at secondary and tertiary levels very successfully while they were engaged in the production and marketing of farm products as well. Lack of support from the state machinery and policymakers resulted in neglect and mismanagement of these farmer companies, finally resulting in the winding up of them within a few years. Therefore, it is compulsory that the lessons learnt from these social engineering experiments need to be considered in further management of PUCs.

   **Policy interventions**: Conduct further studies to understand the reasons for failures of such farmer institutions and reasons for successes if any, in order to understand whether PUCs or any other farmer institute can be organized.

7. Most sites on which ASMP interventions with farmers have been implemented hitherto, fall within either the Agrarian Services Act or under the Land Ordinance for which permits have been issued by the Divisional Secretary. Rarely do such lands have freehold title deeds. Use of these lands for perennial crops and change of physical features like cutting deep drains and digging agro wells etc. are prohibited by the AS Act unless permission is granted individually by the Commissioner General of Agrarian Services.

   In most major and minor irrigation systems there are lands asweddumized for paddy cultivation, but fallowing at least during dry Yala season, and even during Maha seasons. These lands consist of well-draining soils that consume a lot of water if cultivated with paddy but are more suitable for Non-Rice Crops, and even better for perennial crops such as fruit. Paddy cultivated on these lands are more prone to water shortages and yield losses. However, these lands have to be provided with adequate drainage as recommended by the Manual of ASMP if grown with NRCs.

   Permanently diverting such lands that frequently face water shortages in irrigation schemes to fruit crops will reduce the burden on irrigation managers to irrigate such high water-consuming land and focus on an adequate supply of water to paddy crops on clayey soils that will retain water for a long time. OFCs on such lands during the Yala season as an approach for crop diversification will not help in this regard as the land preparation that provides adequate drainage for a seasonal crop during one season (Yala) is costly and difficult to repeat every dry Yala season and then convert back to puddled paddy cultivation during every wet Maha season.

   **Policy interventions:** It is required to make Policy Decisions and necessary legislative amendments to the Agrarian Services Act and Irrigation Ordinance and other relevant legislative tools to facilitate implementing more high-income generating cropping systems that will include perennial crops within the irrigation domain and paddy land environment and diversify from the traditional Rice-based Cropping Systems while ensuring the sustenance of farming livelihood.

8. Seasonal crop cultivation patterns with paddy and rice-based cropping systems in irrigation schemes and rainfed OFC cultivation within upland chena lands, will depend on seasonal water issues from the irrigation source or rainfall. In contrast, a perennial crop will require water during the dry period between the seasons, either within an irrigation scheme or on the upland although the net annual water requirement will be lesser compared to seasonal crops. Therefore, perennial crop cultivation will require an alternative water source to access during a no-irrigation period or to maintain the water supply during a drought period. Farmers in the dry zone are used to dig agro wells in upland chena areas where groundwater is available, but a natural water table cannot be expected in high-elevation areas during the dry months of the year. In contrast, in irrigated areas, the groundwater table exists at a close range of around 4-5 m depth even during dry periods, if the irrigation canals are operated during the season.

   **Policy interventions**: Extensive studies need to be implemented to understand the shallow groundwater table behaviour in order to ensure the reliability of the water source with agro wells.

9. Modernization of the agriculture sector applies to all agricultural systems practised in all the agroecological regions (AERs) in Sri Lanka. Within all AERs, agricultural systems vary between the hydrological endowment that will differently affect the crop growth and production with the assurance and adequacy of soil water. Maintenance of the soil-plant-atmosphere continuum of water is important for optimum crop productivity, whatever the hydrological endowment is.

Based on the hydrological endowment or regimes, 03 agricultural systems are identified within all AERs in Sri Lanka, namely, major irrigation, minor irrigation and rainfed farming (in the North and East rainfed land use system is called Manawari cultivation). A sub-system is identified within all these hydrological regimes (HR) that depends on lift irrigation from agro wells or streams, which are highly productive in the sense of productivity and resource use. Agricultural modernization techniques and technologies are adaptable to all these hydrological regimes in different scales of operation. The micro irrigation techniques, plastic mulching, and solar energy-operated pumping from wells etc. are adaptable with the majority of farming communities and are supreme because they are consistent with climate-smart agriculture. These techniques will relieve the farmers and managers from dependency on reservoirs, diversions and need for huge investments on constructing concrete structures and management interventions. Also, they will ensure the independence of farmers' decisions on what to grow without depending on a state-managed water resource.

**Policy interventions:** It is required to shift the paradigm from investing in huge concrete constructions for irrigation structures but supporting individual farmers to access their own water source from agro wells. The legislations need to be amended to support the concept of independence for individual farmers in selecting their own crop but as a group.

## 8.3 Policy Directives suggested with special reference to individual crops

### 1. Guava

ASMP has considered Guava as a commercially viable crop having potential as a candidate to be adopted for modernizing the agricultural sector. Even with the new technologies adopted through ASMP, there are constraints and limiting factors that hinder the further expansion of Guava, which needs to be addressed at the Policy level and solutions being found.

1) Development of guava as a crop having multiple consumer demands

Sri Lankans have been enjoying guava as a garden fruit with only the ripe fruit being consumed. The variety being grown all over the island is a traditional hardy perennial that will grow in most agroecological regions of the country. The introduction and import of guava fruit from Thailand and other Asian countries have created a new consumption demand and an upsurge in commercial production of guava in the early decade of this millennium. Early commercial-level cultivations started around the Kalpitiya peninsula on sandy regosols with imported varieties such as Thai red and Kilo Pera. Subsequently, the new varieties have been propagated and multiplied by the Department of Agriculture and distributed to many areas.

However, the mode of consumption of Guava of majority is mainly as a fresh fruit while a small portion is absorbed with value addition for cordial preparation. Even then, the fruits of varieties used at present consist of the core with seed which is a trouble for the consumer as well as for the juice industry. Also, Guava is reported to be susceptible to elevated soil water table restricting the growing environments.

**Policy directions:**

a) Research and breeding initiatives required for the development of new guava varieties

– seedless, high yield; core colours with red and white core

b) Research and breeding initiatives required for the development of new varieties that will facilitate product diversion and value addition beyond fresh fruit consumption, towards non-traditional products that will be appreciated in global markets

2) Formulate policies supporting and enhancing guava exports

Currently, export volumes of guava are not very impressive, although guava has been imported from Thailand and other Asian countries to Sri Lanka. Any exports would be in the kind of fresh fruits but not in value-added forms such as fruit juice, frozen cubes, sweetened and dried fruit pieces etc. Also, current guava farmers are not concerned about improving the product into exportable qualities because they earn sufficiently by supplying onto local markets.

**Policy directions:**

a) Research and development initiatives required towards enhancing the quality of the fruits to improve the export potential

b) Infrastructure development required to promote the cultivation of guava in suitable lands and establishment of cold storage warehouses

c) Assistance required to develop industries for value addition and exports

## 2. Banana

Banana is cultivated at present extensively at commercial level in many parts of the island in almost all AERs. Many varieties of banana and plantains are grown within the country of which Embul, and Kolikuttu are considered as plantains and Embun and Ana malu are considered as bananas and are popular and grown extensively. In addition, Dole Banana Company has introduced yellow skinned cavendish banana for export purposes and is cultivated to more than 1000 ha in the country with modern irrigation practices. The ASMP has considered to promote cavendish in Sevanagala of Monaragala and Embul at Rajanagana and Jaffna.

1) Expansion of banana cultivation for export purposes

New technology for banana cultivation under ASMP focuses on the selection of suitable planting material, micro irrigation with fertigation, clump management, bunch management and harvesting at the ideal stage. Also, it is extended to processing with washing, cleaning, sorting and packing for transport to either the local market or the export market. Labour use for desired practices for each of these steps under NT is high when handling a farmer level large plantation (more than ac), but the advantage in price offered at the time of transport is not advantageous when compared with a similar size plantation of ET, even though it is lower than for price offered for fruits under NT. In addition, the uncertainty of the market even with a Forward Sales Contract has discouraged farmers from adopting the NT, even when the quality of fruits is excellent for exports.

**Policy directions:**

a) Incentivize banana export companies to enter into medium term Forward Sales Contracts with farmers groups/clusters who adopt NT as recommended by ASMP, while offering a price with an adequate advantage over the regular farmgate/market price for banana with existing technology (ET) which will attract and encourage farmers to adopt NT.

b) Incentivize export companies to implement effective and efficient value-chain mechanisms, possibly with dedicated service provision for field advisory service focused mainly on banana as a Dedicated Service Provider (DSP) for banana.
c) Facilitate the establishment of banana farmer clusters of at least 400 ha so that the export companies can provide service provision as a contract growing process, ensuring reasonable and sustainable profits for the companies engaged in assisting the export process. However, it is important that procedures should be established to prevent any malpractice or earning of exorbitant profits by the companies at the expense of producers.

2) Ensuring supply of adequate disease-free healthy propagules

For an expanded program of banana cultivation for export purposes under ASMP, it is required to establish planting material suppliers to produce tissue cultured plantlets and peeper production. At present, farmers look for various sources of nurseries to purchase planting material without concern for the quality of the planting material. The most dangerous aspect of banana planting material production is the virus infestation of the source mother plants used for multiplication, which do not show external symptoms of infestation. Although the peepers or tissue cultured plantlets developed from such mother plants may look healthy, viruses may be embedded in the tissues and show symptoms only after a few months of cultivation. Therefore, the use of healthy virus free plants is compulsory for an expanded program of banana cultivation under the concepts of ASMP.

**Policy directions:**

a) Introduce and expand facilities for ELIZA testing (virus testing method) to district and divisional levels (preferably at the Agrarian Services Centre level) so that farmers can be assured of the virus free planting material before purchasing
b) Incentivise the establishment of dedicated nurseries to produce healthy disease free planting material with a medium term estimate of planting material requirement
c) Develop guidelines for the establishment and maintenance of nurseries dedicated to the production of healthy virus-free planting material; they should be registered with an authority listed in the public domain and be strictly monitored.