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Agriculture Sector Modernization Project

OPERATIONAL MANUAL

OKRA

AGRICULTURE SECTOR MODERNIZATION PROJECT

PARK
AGRICULTURE TECHNOLOGY DEMONSTRATION PARK

Prepared by -
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PROJECT DIRECTOR'S MESSAGE

Sri Lanka takes great pride in its rich heritage, with a written history that spans thousands of years. Its fertile soil, diverse landscapes, and strategic location have long made it an ideal hub for farming.

While agriculture evolved globally, Sri Lanka faced challenges. The industry became less profitable and labour-intensive, compounded by the introduction of an open economy. The fragmentation of cultivable land into small, inefficient plots further compounded the challenges as farming was no longer seen as a reliable career.

Sri Lanka allocates a significant portion of its foreign exchange on importing agricultural commodities. Recognizing the potential of its nutrient-rich soil, the government saw an opportunity to cultivate crops that meet international demand while reducing imports and boosting foreign exchange through exports. To capitalize on this, the government prioritized advanced agricultural technologies. In 2017, the "Agriculture Sector Modernization Project" (ASMP) was launched with the World Bank funding.

The project focused on areas where Sri Lanka had the most potential, such as export-oriented tropical fruits and vegetables . It started pilot project in year 2018 with World bank funding with seven districts in five provinces (Jaffna, Mulaithevu, Batticaloa, Anuradhapura, Polonnaruwa, Mathale and Monaragala) and expanded with the grant of the European Union, in another five districts (Kilinochchi, Vavunia, Ampara, Kandy, Badulla) (Kilinochchi, Vavunia, Ampara, Kandy, Badulla) The project secured a loan of USD 64 million from the World Bank, along with a grant of USD 25 million from the European Union. To date, the project has generated USD 65 million in foreign exchange earnings, with potential savings of up to USD 3 million domestically.

The project focused to high-demand tropical fruits and vegetables. Small farms were consolidated into larger groups of 300 to 400 entrepreneurs into Agriculture Technology Demonstration Parks (ATDPs) and modern technologies were introduced.

Tropical Fruit varieties are the main crops selected for Agriculture Technology Demonstration Parks of the Agriculture Sector Modernization Project (ASMP) by the International Service Provider (ISP) identified as Tropical Queens (Banana, Mango, Guava, Papaya and Pomegranate) which are among the most popular fruits in the world. ISP engaged in producing those competitive and marketable commodities for both local and export markets

The socio-economic problems and the COVID pandemic of the Country during year 2020- 2022 affected the implementation of the ISP technology packages. Because of this, the ISP and the ASMP developed optional technology packages, designed to overcome the shortfalls of the crisis. Procurement of equipment and supplies already available in the Country was given priority to avoid import delays and constraints. Different irrigation systems were used when the preferred system was not available. Options are also being developed for inputs such as fertilizers and pesticides. Intercropping was implemented as the ideal weed control practice and staple food crops to provide much-needed food to the Country. More emphasis is given to IPM systems to control pests and diseases. Even existing crops were given pre- and post-harvest technology to start exports without waiting until newly planted crops are harvested. Therefore, most of ASMP crop clusters have both existing crops and new crops with complete ISP technology package. Therefore, the *Operational Manuals* of Dr Julian; the Agronomist of ISP are based on technology for both existing crops of farmers as well as new crops with entire technology package .

ASMP started with Pilots by introducing Department of Agriculture (DOA) technology. With the intervention of Dr. Julian, ASMP involved in Vertical upliftment of the existing DOA technology from land preparation to pre / post-harvest technology to end up with modern processing technology with reefer container protocol for export which have never been practised in Sri Lanka . High density double Row planting, Low pressure irrigation (mini sprinklers, Drip tapes), irrigation based on mini whether station data , soil test based fertigation, modern training and pruning of fruit trees (box and espalier), use of poly mulch , pre and post- harvest Technology (use of colour bagging , colour ribbons, fruit desk etc) are some of the promising technologies introduced by the ISP. ASMP has produced Operational Manuals for Banana (*Ambul, Kolikuttu, Cavendish*), Mango, Guava , Papaya, Soursop, Passion fruit, chilli, Vegetables , Jumbo peanut, potato , Red onion and Maize .

The project introduced innovative methods for increasing land productivity. Techniques like high-density double-row planting and the "espalier" method allowed agroprenuers to double or even triple their yields. Automated water-controlling systems based on weather station data ensured a effective use of water supply, enhancing productivity reducing use of fertilizer. Solar energy was harnessed to power these systems, reducing reliance on the main electricity supply..

Over the past seven years, the project had transformed the concept of "farming" in Sri Lanka. Once viewed as an unattractive profession, farming had become a thriving opportunity, attracting the new generation. This shift had marked a major change in societal attitudes and had empowered farmers as **agropreneurs**, driving innovation and growth in the agricultural sector.

A key initiative of the project was the transition from individual farming to the establishment of farmer companies. Farmers were organized into "Public Unlisted Companies (PUC)," raising the status of farming from a mere livelihood to an esteemed profession. This shift established a structured system, elevating agriculture to a professional level and instilling a sense of pride in the farming community.

Farmers of the Agriculture Technology Demonstration Parks of the Agriculture Sector Modernization Project (ASMP) were organized into Farmer Producer groups and these groups were later registered as Farmer Companies under the Companies Act No 7 of 2007, in the Public Unlisted Company category. There are 59 Farmer Companies already functioning in the ASMP crop clusters.

The Farmer Company model facilitated direct business transactions between local farming organizations and international buyers, creating new global business opportunities

Specialized processing centres for each Farmer Company ensure that crops are processed, graded and packaged according to international standards. This system provides the buyers with access to high-quality products through a structured, well-organized, and accountable framework, ensuring benefits for both agropreneurs and buyers alike.

Dr. Rohan Wijekoon
Project Director
Agriculture Sector Modernization Project

Contents

1. INTRODUCTION

Okra *(Abelmoschus esculentus)*, also known as lady's fingers or gumbo, is a popular warm-season vegetable that is cultivated for its edible green pods. It is widely appreciated for its distinctive flavor, versatility in cooking, and nutritional benefits.

Okra is believed to have originated in tropical Africa, specifically in the regions of Ethiopia and the Sudan. From there, it gradually spread to different parts of the world, including Asia, Europe, and the Americas. Okra has been cultivated for centuries and has become an integral part of numerous culinary traditions across the globe.

Okra plants are herbaceous annuals, belonging to the Malvaceae family. They typically grow as upright, branching, and tall plants, reaching heights of around 3 to 6 feet (1-2 meters). The leaves are large, lobed, and palmate, with a vibrant green color. The flowers are hibiscus-like, featuring five petals that are typically yellow or white with a purple or red center.

The most distinctive feature of okra is its elongated, ribbed pods. These pods are usually around 4 to 10 inches (10-25 cm) long, although there are different varieties with varying pod lengths and shapes. The pods are green when young and turn tougher and fibrous as they mature. Inside the pods, numerous small and round seeds are embedded.

1.1 Optimal Ecological Requirements

Okra is a warm season crop that thrives in regions with long, hot summers. The optimal growing conditions for okra are:

1. **Temperature:** Okra plants require temperatures between 75°F and 95°F (24°C - 35°C) for optimal growth. They are sensitive to frost and cannot tolerate temperatures below 50°F (10°C). Planting should be timed accordingly to ensure warm conditions throughout the growing season.
2. **Sunlight:** Okra plants require full sun exposure to thrive. They need a minimum of 6 to 8 hours of direct sunlight each day.
3. **Soil:** Okra prefers well-draining soil that is rich in organic matter. A slightly acidic to neutral soil pH of 6.0 to 7.5 is ideal. The soil should be loose and loamy, allowing for proper root development and water drainage.
4. **Rainfall:** The ideal rainfall requirement for okra cultivation is around 25 to 35 inches (63.5 to 88.9 cm) per year. This includes both rainfalls received during the growing season and any supplemental irrigation provided. However, it's important to note that the specific water needs may vary depending on factors such as local climate, soil type, and stage of growth.

During the initial stages of growth, okra plants require consistent moisture to establish and develop strong root systems. Adequate watering is especially important during flowering and fruiting, as water stress can result in poor fruit set and yield.

2. LAND PREPARATION

2.1 Primary Land Preparation

1. Deep ploughing using a 60 cm diameter disk plough.
2. Incorporation of organic matter (Commercial Compost) by broadcasting 12 MT per hectare or 5 MT per acre of compost
3. Deep plough again perpendicular to the first pass

2.2 Secondary Land Preparation

1. Heavy Soil Textures
    a. Disk harrow using a disk harrow implement with disks having a diameter of 40 cm
    b. Two passes perpendicular to each other are required.

2. Light Soil Textures
    a. Cultivate using a tine tiller implement.
    b. Two passes may be required in sandy clay loam soils.

2.3 Tractor

1. Tractor size 75 to 99 HP (75 to 85 POT), four-wheel drive

2.4 Drainage

Drainage is of particular importance for the Okra as the crop is susceptible to several root diseases. Good internal drainage provided by raised beds (50 cm high) and a network of drainage ditches to quickly evacuate high amounts of rainfall are very important practices to prevent root rots and other soil borne diseases affecting Okra.

1. **Light Texture Soils:**
   Light textured soils are preferred for the cultivation of the Okra.
    - Sloping handmade ditches to evacuate water from rainfall quickly 30 cm wide x 15 cm deep.
    - These ditches will discharge into a larger sloping drainage trench 75 cm wide with a depth between 45 cm to 60 cm according to the conditions of the land.
    - This is a "U" type drainage design for small plots made up of two lateral drainage ditches at the extreme ends of the plot that drain into a primary drainage canal that evacuates the water away from the plot.
    - Before making the ditches, it is necessary to observe the slope of the plot and the East-West direction of the double row planting. Ideally, the double rows should drain into the lateral ditches without much effort.
2. Heavy Texture Soils:
   Heavy texture soils such as clays are not very suitable for Okra cultivation.
    - Sloping drainage secondary canals 45 cm wide x 30 cm deep at 20 m intervals.
    - These canals will discharge into a larger primary type sloping drainage canal 1 m wide with a depth of 60 cm according to the conditions of the land.
3. Waterlogged Soils
   This type of soil must be avoided for Okra cultivation.
    - Drainage lines 45 cm wide and 45 cm to 60 cm deep at 5 m to 10 m intervals.
    - These lines will discharge into a larger primary type sloping drainage canal 1 m wide with a depth of 60 cm according to the conditions of the land.
4. Drainage Equipment
    - Backhoe Excavator or similar with 30cm or 45cm wide bucket

3. VARIETIES[1]

In Sri Lanka, there are several varieties of okra that are commonly used and enjoyed for their culinary and nutritional value. One of the popular okra varieties is the Clemson Spineless, known for its tender pods and lack of spines, making it easy to handle and cook. Another commonly grown variety is the Emerald Okra, prized for its vibrant green color and excellent flavor. The Annie Oakley II is another favored variety, known for its high yield and disease resistance, making it a reliable choice for farmers. Additionally, the Red Burgundy Okra is gaining popularity for its striking red pods, adding a touch of visual appeal to dishes. These different okra varieties provide Sri Lankan cuisine with a range of options, allowing for diverse and delicious culinary creations.

[1]The variety was chosen to satisfy the demands from the international market for a longer length okra finger of at least 10 cm. Moreover, only straight okra fingers are accepted in these markets. Approved DOA varieties must comply with the specifications demanded by the international market.

4. HIGH DENSITY PLANTING

Okra seeds can be directly sown into the soil. Seeds are planted about 1 inch (2.5 cm) deep in the soil.

4.1 Procedure

The Okra is planted in beds made by mechanical bed-makers pulled by tractors. Beds can also be made by hand. The beds should be 60 cm wide and 50 cm high and are separated by a ditch 30 cm wide. This means the total distance from center to center of two adjacent beds is 90 cm. The height of the bed is very important for Okra for the prevention of soil borne diseases and to improve internal drainage and allow the root system to have ample space to develop and grow.

Figure 1: Bed Preparation

Figure 2: Drip Tape Installation

After making the beds, two drip tape lines are installed towards the middle of the bed and on the inside of the planting bed for irrigation purposes. This double drip tape system is preferred due to the large plant size above and below the ground and because of the high population density that creates a very large evapotranspiration surface area.

The drip tape is double layer, white in color and UV resistant (the outer layer is UV treated). Its wall is 0.30 mm thick, and the tape has a 16 mm diameter. Emitters are spaced at 30 cm on the tape and the flow rate for the emitters is 2 Lt/Hr at 1 Bar of pressure. The drip tape is followed by the installation of a silver and black plastic mulch with a thickness (gauge) between 30 microns to 40 microns and a width of 5 ft (1.52 meters).

Two rows of plants are placed on every bed. The distance between the two rows is approximately 40 cm to 45 cm. The planting distance (spacing) inside the planting rows of 40 cm is then marked on the mulch with a planting guide or template that uses sharp nails to make planting marks. The planting pattern for the two rows of the crop on every bed should be triangular to minimize the high-density effect on plant-to-plant competition. This planting pattern is always preferred for high density planting.[2]

> Plastic mulch, combined with drip tape irrigation, high planting beds and high-density planting is considered the current "state of the art" technology for high value crop production. The combination is one of the most efficient and productive systems for maximizing both yields and irrigation efficiency.

[2] According to DoA, It is mentioned 40 cm by 40 cm while actual root distribution pattern does upto to 45 cm. It is proposed to conduct 3-4 preliminary studies before applying this technology in large-scale commercial-level cultivation. As per ISP, due to triangular planting pattern recommended by the ISP, the true distance between neighboring plants is 49 cm

Figure 3: Mulching

POPULATION DENSITY

56,000/Ha
22,400/Acre
11,200/Half Acre

The mulch is then perforated by using very hot iron or aluminum cylinders such as discarded processed food aluminum cans. The metal cylinders are kept red hot with burning charcoal.

For planting purposes, all distances are carefully measured and staked out in the field with construction twine in order to achieve the desired population density as precisely as possible

4.2 Plant Spacings Within the Crop Rows

Okra	0.40 m

4.3 Planting Aids

1. Construction twine (preferably white colored)
2. A good number of wooden stakes to layout base lines and crop rows
3. Previously made planting templates
4. Measuring tape
5. Markers

5. IRRIGATION AND FERTIGATION

5.1 Irrigation

Okra requires 6 mm per day of water for optimum production. Low pressure irrigation is the best method of applying uniform and precise amounts of water directly to the root zone of the plants, as per their above requirement, through emitters at frequent intervals over a period, via a pipe network comprising of mains, submains, and laterals. In this case the system is a drip tape system that applies water drop by drop to maintain the soul moisture at field capacity.

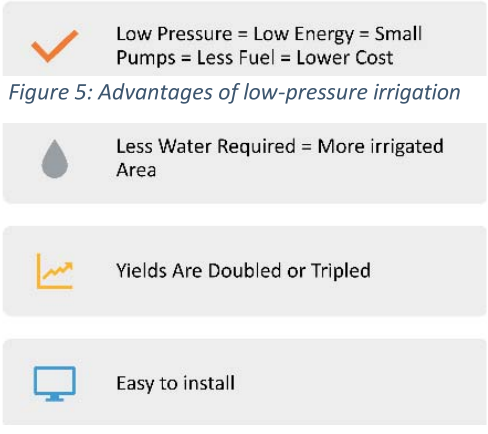

Figure 5: Advantages of low-pressure irrigation

Figure 4: Drip Irrigation System

5.2 New Irrigation Concepts

- Net Area Irrigation – Water for Cultivated Area Only
- Evapotranspiration for irrigation scheduling rather than soil moisture content.

- Consumptive Water Use by Crops: Different Crops Different Amounts of Water
- Water Amounts Are Adjusted to The Physiological Development of the Crops (Kc Constants per Crop)

5.3 Water Application

The Okra consumptive water use of 6 mm of water per day is equivalent to 42 mm per week. This weekly amount can be applied in 3 cycles. Under this application regime, the chart below is the recommended irrigation time per cycle to irrigate half an acre of Okra in Polonnaruwa using the drip tape irrigation system with two drip tapes lines in the middle of the planting bed separated at approximately 30 cm to 40 cm.

Table 1: Irrigation Schedule

Irrigation Schedule	1-4 week		5-11 week		12-17 week	
Irrigation Time (Hours/ Minutes)	0	34	0	58	0	43

5.4 Fertigation

Okra is a heavy feeder and benefits from a nitrogen-rich fertilizer regime to support vigorous vegetative growth. However, a balanced nutrition program is required for optimum yields. Monitoring the soil pH is critical as okra prefers slightly acidic to neutral conditions with a pH range of 6.0 to 7.5.

Regular soil testing can help determine if any specific nutrient deficiencies or imbalances need to be addressed. By providing adequate and balanced fertilization, gardeners can ensure that their okra plants grow vigorously and produce a bountiful harvest.

Other nutritional requirements for Okra include major and minor nutrients as follows:

- Phosphorus is essential for root development and early growth.
- Potassium is crucial for overall plant health, disease resistance, and pod quality.
- Although required in smaller quantities, micronutrients such as iron, manganese, zinc, and boron are also important for Okra.
- Maintaining a balanced nutrient ratio is important for optimal growth. The ideal nutrient ratio for Okra is often expressed as N-P-K, with varying ratios depending on the soil test results and specific Okra variety.

For the vegetables Cluster in Polonnaruwa, fertilizer application is based on soil test results (Annex 2). Soil test results are interpreted using critical levels of nutrients and several other chemical and physiological considerations to develop a complete fertilizer recommendation.

The results for the soil tests for the Okra Cluster in Polonnaruwa indicated the following:

Organic matter low in about 40% of the samples
Potassium Low also in 49% of the samples
Soluble Nitrogen low
Sulphur, Manganese and Zinc low
The Cation ratios are low. Of concern is the narrow Mg/K ratio. Mg as a soil amendment is needed[3]
The Calcium saturation is high. The soil amendment with Mg will reduce the Ca saturation as well

[3] Magnesium is not recommended as a nutrient by the ISP. It is recommended as a soil amendment to improve the chemistry of the soil cation exchange complex and make the soil more fertile and productive. Small supplemental quantities of Mg from 50 Kg/Ha to 100 Kg/Ha (0.21 meq to 0.42 meq of the Mg^{2+} ion) are recommended. Because the concentration of Mg in fertilizer grade MgSO4 is only 10%, a large application of the fertilizer is required to supply to the soil with a low amount of the Mg^{2+} ion.

Therefore, the recommendations for the application of fertilizers for this soil test are as follows:

Nitrogen as required by the crop
Potassium as MOP
$MgSO_4$ as soil amendment and to supply required Sulphur
Foliar applications of micronutrients
Mostly Manganese and Zinc

Based on the above considerations, the amount of nutrients to be applied is in elemental and oxide form:

Recommendation	N	P	K	Mg
Kg/ Ha	175	3	150	100
Lb/ acre	175	3	150	100
Kg/ acre	79.5	1.4	68.2	45.5

Table 2: Nutrition Quantities

Recommendation	Urea	P_2O_5	K_2O	MgO
Kg/ Ha	380.4	6.9	248.7	165.8
Lb/ acre	380.4	6.9	248.7	165.8
Kg/ acre	172.9	3.1	113	75.4

For these amounts, the quantities of fertilizer materials per year (season) are:

Kg/ Acre	Urea	P Acid	MOP	$MgSO_4$
Fertilizer per year (Season)	173	5	188	455

Table 3: Quantities of fertilizer materials per year (season)

Considering the stage of development of the crop, the quantities of fertilizer materials required per season are:

Kg/ Acre	Emergence	Development	Maturity	Total
Urea	57	59	57	173
P Acid	1.7	1.8	1.7	5.2
MOP	62.2	64.1	62.2	188
$MgSO_4$	150	154.5	150	455

Table 4: Quantities of fertilizer as per stage of development

Considering an Okra crop cycle in Sri Lanka of 13 weeks, the potential number of fertigation weeks is also 13 weeks. Thus, the fertilizer quantities per Acre per week are as follows:

Kg/Acre/ Week	Emergence	Development	Maturity
Urea	13.32	13.72	12.89
P Acid	0.40	0.41	0.39
MOP	14.51	14.95	14.04
$MgSO_4$	35	36.06	33.87

Table 5: Week-wise, fertilizer quantities

These amounts are to be applied in 2 cycles per week. On a per application basis (irrigation cycle), the amounts of fertilizer materials required are:

Kg/Acre/ Application	Emergence	Development	Maturity
Urea	6.658	6.859	6.443
P Acid	0.802	0.826	0.776
MOP	7.3	7.5	7.0
$MgSO_4$	17.5	18	16.9

Table 6: Fertilizer quantities, as per application basis (irrigation cycle)

These amounts are further reduced based on the net area cultivated in Okra. For a production plot with a size of half an Acre, the net area to be fertigated is only 0.34 Acres. Following are the fertigation recommendations for this net area:

Kg/Acre/Application	Emergence (Week 1-4)	Development (Week 5-11)	Maturity (12-17)
Urea	2.26	2.33	2.19
MOP	2.5	2.5	2.4
$MgSO_4$	5.9	6.1	5.7
Applications per week	2		
P Acid Application every two weeks (ml)	161.5	166.4	156.3
Foliar Applications of Micronutrients Weekly or Bi-Weekly, Especially Mn and Zn			

Table 7: Fertigation recommendation per application per plot

In addition, foliar applications of micronutrients are required on a weekly basis, especially Manganese (Mn) and Zinc (Zn).

6. WEED CONTROL

Weeds are controlled using agricultural type plastic mulch which offers several distinct advantages in agricultural applications:

- One of its primary benefits is weed suppression, as the opaque nature of the mulch effectively blocks sunlight, preventing weed growth and reducing the need for chemical herbicides.
- Additionally, plastic mulch helps to conserve soil moisture by minimizing evaporation, thus supporting more efficient water use and reducing the frequency of irrigation.
- The mulch also serves to warm the soil, promoting earlier planting and enhancing overall crop development, particularly in cooler climates.
- Furthermore, the use of plastic mulch can lead to improved fruit and vegetable quality by preventing direct contact with the soil, reducing the risk of rot and spoilage.

Overall, plastic mulch contributes to increased crop yields, improved crop quality, and more efficient use of resources, making it a valuable tool in modern agricultural practices.

Nevertheless, while plastic mulch offers several benefits in agriculture, including weed suppression, soil moisture retention, and increased soil temperature, it also presents several notable management challenges:

- The prolonged use of plastic mulch using non-biodegradable materials can lead to pollution and soil contamination when left in the field for a long time after the cropping season.
- Unproper disposal of plastic mulch can result in visual pollution in agricultural areas and contribute to long-term soil degradation.
- The use of plastic mulch as a continuous field practice, crop after crop, can impede natural soil aeration and microbial activity, potentially disrupting the soil ecosystem, and causing the accumulation of plastic residues in the soil.
- The cost of purchasing and removing plastic mulch, as well as the labor involved in installation and disposal, can be significant but are alleviated by the financial returns from the higher yields and better quality obtained with plastic mulch, particularly for small farmers.
- The use of plastic mulch must be accompanied by drip tape irrigation and high planting beds to avoid excess water runoff that causes the loss of nutrients that can lead to environmental contamination, impacting surrounding water sources.
- The accumulation of water on the surface of the plastic mulch from rainfall and/or irrigation must be prevented to avoid the possibility of waterlogging in some instances.
- The physical barrier between the soil and the atmosphere caused by plastic mulch can interfere with the natural nutrient cycling processes, potentially leading to imbalances in soil nutrient levels and impacting long-term soil fertility when fertigation is not practiced using the drip tape irrigation system.

If there is a need to control weeds by other means, only mechanical weed control practices are to be used. Herbicides are not allowed for social and environmental reasons. The most common mechanical weed control practices are:

1. Cultivation with a tractor using a rotavator implement.
2. Motorized weed cutters that use plastic cords to cut weeds (weed eaters).
3. Workers use bush knives or any other cutting or chopping tool.

7. PEST AND DISEASE CONTROL

IPM concepts and practices must be applied to manage Okra pests and diseases. The Quantity/Intensity factor is a practical and easy to apply IMP concept in deciding whether to apply pesticides:

Quantity	**Coverage**		
Intensity	**Severity**		
Intensity	**Low**	**Medium**	**High**
Low	Observation	Observation	Localized
Medium	Spot Treatment	Localized	Full Treatment
High	Localized Treatment	Full Treatment	Full Treatment

7.1 Peripheral Insect Net

The use of insect nets represents a highly effective and environmentally friendly method for protecting crops from insect pests as part of an IPM approach. By strategically protecting crop fields with peripheral fine-mesh insect nets, farmers can create a physical barrier that prevents harmful insects from reaching the plants, thereby reducing the need for chemical pesticides. These nets serve as a protective shield, effectively blocking the entry of a wide range of pests, including aphids, thrips, whiteflies, and caterpillars, while also providing a barrier against certain diseases carried by insects. Furthermore, insect nets allow for the passage of air, light, and water, ensuring that crops receive the necessary resources for healthy growth. With the ability to significantly reduce pest damage and minimize the risk of crop losses, the use of insect nets demonstrates a sustainable and integrated approach to crop protection, contributing to both higher yields and the promotion of eco-friendly agricultural practices.

Designing an acre-sized peripheral insect net for Okra plants would require careful planning and a significant number of materials. Here's a conceptual design for an acre-sized peripheral insect net, along with estimated quantities of materials required:

Design:

1. Support Structure:	• 8 to 9-feet wooden or metal poles placed every 15 feet along the perimeter of the acre. • Galvanized wire or strong twine to connect the poles at the top to form a framework for the net.
2. Netting:	• High-quality, fine mesh netting that is durable and provides ample protection against insects and pests. • The netting should be large enough to cover the entire acre, with some extra for securing it to the ground. • The height of the insect net should be at least 2 m.
3. Anchoring System:	• Ground stakes or sandbags to secure the netting to the ground and prevent it from being blown away by wind.
4. Access Points:	• Zippers or flaps within the netting to allow entry and exit for workers and equipment.

Materials Required (estimated for an acre):

1. Support Structure:	• Wooden or metal poles: 80 poles (assuming poles are placed every 15 feet). • Galvanized wire or strong twine: Approximately 3,000 feet.
2. Netting:	• High-quality, fine (40 mesh to 60 mesh) mesh netting: • Approximately 2 acres of netting to allow for overlap and secure attachment.
3. Anchoring System:	• Ground stakes or sandbags: Approximately 200 stakes or sandbags.

4. Access Points:	• Zippers or flaps: 6-8 heavy-duty zippers for access points.

These quantities are estimates and may vary based on the specific design, quality of materials, and other factors. It's important to consult with a professional or supplier to determine the exact requirements for your specific project.

Insecticides are often sprayed on insect nets to enhance the effectiveness of pest control measures. Insect nets serve as a physical barrier to prevent insects from reaching crops or protected areas, but their efficacy can be further heightened by treating them with insecticides. This dual approach provides a comprehensive solution by combining the mechanical barrier of the net with the chemical action of the insecticide. The insecticide helps to repel, deter, or kill insects that come in contact with the net, offering an added layer of defense against pests. This integrated approach not only safeguards crops more comprehensively but also contributes to sustainable pest management practices, reducing the reliance on excessive chemical applications on the surrounding environment. It ensures a more targeted and efficient use of insecticides, promoting a balanced and environmentally conscious approach to crop protection.

Usually, Abamactine at 26 ml per 16 L knapsack spray tank is used for mites and Imidachlorophid for thrips at 20 ml per 16 L knapsack spray tank every 10 days, alternating the products. During the dry season, the application intervals could be increased to 2 weeks if pest activity is low.

7.2 Yellow Sticky Traps

Figure 6: Yellow Sticky Traps

Yellow sticky traps play a crucial role in integrated pest management strategies for field crops, offering farmers a valuable tool for monitoring and controlling insect populations. By strategically placing these traps throughout crop fields, farmers can effectively monitor insect populations and identify potential threats to the crops. The bright yellow color of the traps acts as a powerful attractant for a wide variety of flying insects, including aphids, thrips, leafhoppers, and other pests known to damage field crops. Once captured on the adhesive surface of the traps, these insects are effectively removed from the crop environment, helping to mitigate potential yield losses and reduce the need for chemical insecticides. By incorporating sticky yellow traps into their pest management plans, farmers can contribute to the sustainable and environmentally conscious cultivation of field crops, promoting healthier yields and minimizing the impact of harmful pests on agricultural production.

Sticky yellow traps are typically coated with a bright yellow, non-drying adhesive that attracts a wide range of flying insects. Once insects come into contact with the sticky surface, they become firmly trapped, preventing them from causing further damage to plants. The yellow color of the traps is particularly attractive to many types of insects, making them a popular choice for both professional growers and home gardeners.

Environmentally friendly and easy to use, sticky yellow traps serve as a valuable tool in integrated pest management strategies, helping to maintain healthy plant growth without the need for harmful chemical pesticides.

Figure 7: Okra Field

For Okra, sticky yellow traps are placed at 10 m intervals along the edge of the planting beds, alternating the side of the bed they are placed on. This arrangement creates a network of protection against harmful insects, especially white flies.

7.3 Most Common Pests and Diseases in Okra in Sri Lanka

Okra *(Abelmoschus esculentus)* is a warm-season vegetable that is widely cultivated for its edible green pods. However, like any other crop, okra is susceptible to various pests and diseases that can significantly impact its yield and quality.

a) Aphids

- **Life Cycle**: Aphids are small, soft-bodied insects that suck sap from the plant, causing stunted growth and deformation of leaves. They reproduce rapidly, with females giving birth to live young.
- **Control Measures:** Non-chemical control includes introducing natural predators like ladybugs or lacewings. When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Figure 8: Aphids

b) Whiteflies

- **Life Cycle:** Whiteflies are tiny, white-winged insects that feed on the undersides of leaves, causing yellowing, wilting, and reduced plant vigor. They lay eggs on the undersides of leaves.
- **Control Measures:** Non-chemical control includes using yellow sticky traps to monitor and trap adult whiteflies. When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Figure 9: Whiteflies

c) Fruit Borers

Figure 10: Fruit Borers

- **Life Cycle:** Fruit borers, such as the Okra Fruit Borer, lay eggs on the surface of young fruits. The larvae bore into the fruit, causing damage and leading to fruit rot and reduced market value.
- **Control Measures:** Non-chemical control involves inspecting plants regularly and removing infested fruits. When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

d) Leafhoppers

- **Life Cycle:** Leafhoppers are small, wedge-shaped insects that feed on plant sap, leading to yellowing, wilting, and reduced plant growth. They transmit diseases such as leaf curl virus.
- **Control Measures:** Non-chemical control includes removing weeds and infected plants. When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Figure 11: Leafhopper

e) Powdery Mildew

- **Life Cycle:** Powdery mildew is a fungal disease characterized by a white, powdery growth on leaves, stems, and pods. It thrives in warm and humid conditions.
- **Control Measures:** Non-chemical control involves ensuring proper air circulation and avoiding overhead irrigation. When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Figure 12: Powdery Mildew

f) Fusarium Wilt

Figure 13: Fusarium Wilt

- **Life Cycle:** Fusarium wilt is a soil-borne disease caused by the fungus Fusarium oxysporum. It causes wilting, yellowing, and stunting of plants, eventually leading to plant death.
- **Control Measures:** Non-chemical control involves crop rotation, soil solarization and good drainage. When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

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g) Root Knot Nematodes

- **Life Cycle:** Root knot nematodes are microscopic roundworms that infect the roots, causing galls, stunting, and reduced nutrient uptake. They have a complex life cycle involving several stages.
- **Control Measures:** Non-chemical control includes practicing crop rotation with non-host plants. When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Figure 14: Root Knot Nematodes

Integrated Pest Management (IPM) practices that combine non-chemical and chemical control measures are recommended to minimize environmental impact. For chemical control, it is essential to consult local agricultural authorities such as the DOA and follow label instructions for specific pesticide recommendations and application rates, as they may vary based on location, regulations, and pest/disease severity.

8. HARVESTING

8.1 Maturity Indexes

Determining the appropriate maturity stage of okra is essential to achieve the desired quality. The following maturity indexes can be used as a guideline:

a) **Pod Length:** Okra pods should typically be harvested when they reach a length of 3-4 inches (7.5-10 cm). Pods that exceed this length may become tough and fibrous, affecting their taste and tenderness.
b) **Color:** Harvest okra when the pods are still uniformly green. Avoid harvesting if the pods have turned yellow or brown, as this indicates over-ripeness and a decline in quality.
c) **Texture:** Young and tender okra pods have a smooth, firm texture. As they mature, pods become harder and develop ridges. Harvest okra when the pods are still smooth and easy to cut with a knife.
d) **Seed Development:** Check the seeds inside the okra pods. Harvest when the seeds are small, soft, and immature. Overdeveloped seeds can make the pods tough and decrease their culinary appeal.

8.2 Harvesting Procedures

To ensure optimal flavor and quality, follow these recommended procedures for harvesting okra:

a) **Timing:** Okra pods should be harvested every 2-3 days, as they grow rapidly. Regular monitoring is crucial to prevent over-ripening and ensure that the pods are harvested at the right stage.
b) **Tools:** Use a pair of sharp pruning shears or a knife to harvest okra. Dull tools can damage the plant or result in uneven cuts.
c) **Handling:** Gently hold the stem of the okra pod and cut it off just above the cap. Avoid applying excessive pressure or twisting, as this can cause damage to the plant.
d) **Harvesting Frequency:** Remove all mature okra pods during each harvesting session. Leaving overripe pods on the plant can hinder the production of new pods.
e) **Storage:** After harvesting, place the okra pods in a basket or container lined with a clean cloth or paper towel. Store them in a cool and well-ventilated area or refrigerate them to maintain freshness.

Figure 15: Okra Harvesting

8.3 Additional Tips for Harvesting Okra

a) Harvest okra in the morning when the pods are crisp, and their moisture content is optimal.
b) Avoid harvesting okra after rainfall or when the plants are wet, as this can increase the risk of spoilage during storage.
c) If you encounter any damaged or diseased pods, remove them immediately to prevent the spread of diseases and maintain the overall quality of the crop.
d) Proper post-harvest handling, such as pre-cooling and packaging, is essential if you intend to sell or store okra for an extended period.

9. POST-HARVEST HANDLING

9.1 Okra Post Harvest Profile

Maturity Indices

Okra pods are immature fruits and are harvested when they are very rapidly growing. Harvest typically occurs 3 to 7 days after flowering. Okra should be harvested when the fruit is bright green, the pod is fleshy, and seeds are small. After that period, the pod becomes pithy and tough, and the green color and mucilage content decreases.

Quality Indices

Okra pods should be tender and not fibrous and have a color typical of the cultivar (generally bright green). The pods should be well formed and straight, have a fresh appearance and not show signs of dehydration. Grade is U.S. no. 1. Pods are packed based on length with Fancy, Choice, and Jumbo designations for size categories. Okra should be free of defects such as leaves, stems, broken pods, insect damage, and mechanical injury. The tender pods are easily damaged during harvest, especially on the ridges and this leads to unsightly brown and black discoloration. Quality losses that occur during marketing are often associated with mechanical damage, water loss, chilling injury, and decay.

The darkening of okra skin after harvest is a severe quality defect of Okra and is primarily due to enzymatic browning, a natural chemical reaction that occurs when the vegetable's cells are damaged or exposed to air. When okra is harvested, its skin is often susceptible to scratches, cuts, or bruises, which can trigger the release of enzymes called polyphenol oxidases. These enzymes cause compounds in the okra, such as phenols, to react with oxygen, resulting in the formation of dark pigments known as melanins. This process is accelerated by higher temperatures and high humidity, causing the skin to turn black or dark relatively quickly. Proper handling and storage, such as refrigeration and minimizing physical damage, can help slow down the enzymatic browning process and maintain the okra's visual appeal and quality.

Washing or wetting okra after harvesting can contribute to the darkening or blackening of its skin. When okra comes into contact with water, especially if it is not promptly dried, the moisture can lead to increased enzymatic browning. Water can activate the enzymes present in the okra, prompting them to catalyze the oxidation of phenolic compounds in the vegetable, resulting in the formation of dark pigments. Additionally, wet okra is more susceptible to microbial growth, which can further accelerate the deterioration of the vegetable's skin. Therefore, minimizing the contact of harvested okra with water and ensuring thorough drying before storage can help prevent or slow down the darkening of its skin.

Optimum Temperature

7-10°C (45-50°F)

Very good quality can be maintained up to 7 to 10 days at these temperatures. If stored at higher temperatures, the pods lose quality due to dehydration, yellowing and decay. When stored at lower than recommended temperatures, chilling injury will be induced (see physiological disorders). Chilling symptoms include surface discoloration, pitting and decay. Okra can be successfully hydrocooled or forced air cooled.

Rates of Respiration

Okra pods have very high respiration rates.

Optimum Relative Humidity

Weight loss is very high in immature okra pods and cultivars may vary in rate of water loss. A very high relative humidity (95-100%) is needed to retard dehydration, pod toughening, and loss of fresh appearance.

Rates of Ethylene Production

Okra pods have low ethylene production rates.

Responses to Controlled Atmospheres (CA)

Okra is not stored in modified atmospheres commercially. At recommended storage temperatures, CO2 concentrations of 4-10% can help maintain green color and reduce discoloration and decay on damaged pods. CO2 concentrations higher than 10% can lead to off flavors. Low O2 concentrations (3-5%) reduce respiration rates and may also be beneficial.

9.2 Post Harvest Handling

Post-harvest management of Okra is a critical aspect of ensuring the quality and marketability of the crop. Proper handling, storage, and processing practices are essential to minimize losses and maintain the nutritional value of the Okra.

1. **Sorting:** After harvesting, okra should be sorted to remove damaged, diseased, or overripe pods. The sorting process helps in maintaining a uniform quality for export.
2. **Cleaning:** Okra pods should be gently cleaned to remove any dirt, debris, or surface contaminants. It is recommended avoid the use of water or sanitizing solutions to prevent the blackening of the skin.
3. **Cooling:** Rapid cooling is essential to preserve the freshness of okra. The pods should be immediately cooled to a temperature of around 7°C -10°C (45°F -50°F) to slow down respiration and reduce metabolic activity.
4. **Packaging:** Okra should be packed in suitable containers to protect it during transportation. The most used packaging materials for okra export include crates, plastic boxes, or cartons. These containers should be well-ventilated to allow airflow and minimize condensation.

9.3 Packing Procedures for Export

1. **Sizing:** Okra pods can vary in size, and it is recommended to sort them into uniform sizes for packing. Common size ranges for export include small (2-3 inches), medium (3-4 inches), and large (4-5 inches) pods. However, specific size requirements may vary based on export regulations and customer preferences.
2. **Net Weight of Export Boxes:** The net weight of export boxes commonly used for okra varies depending on factors such as market requirements, transportation methods, and destination. However, a standard export box commonly used for okra typically weighs between 5 kg (11 lbs) and 10 kg (22 lbs).
3. **Labeling:** Each export box should be properly labeled with essential information, including product name, origin, batch/lot number, size, and weight. Labeling ensures traceability and assists in meeting import regulations.
4. **Storage and Transportation:** Okra should be stored in cool conditions to maintain its quality. During transportation, it is important to avoid exposure to direct sunlight, excessive heat, or prolonged periods without refrigeration.
5. Regular quality checks should be conducted to ensure that the okra meets the desired standards. Quality control measures may include visual inspection, monitoring temperature and humidity, and conducting periodic shelf-life tests.

9.4 Packing Centre Layout

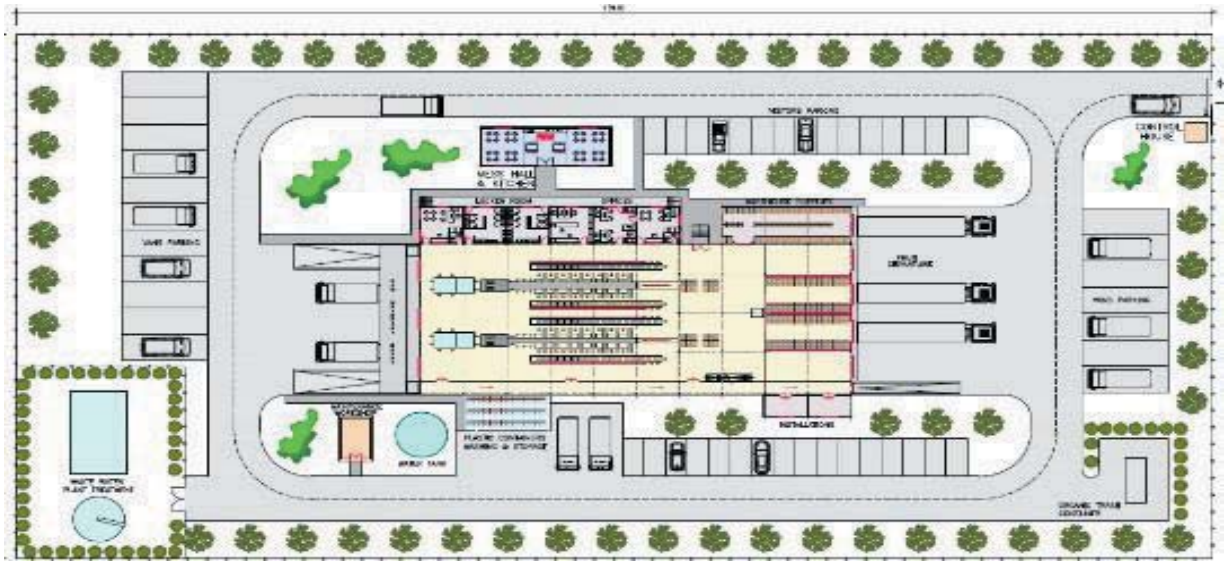


Figure 16: Packaging Centre Layout

9.5 Packing Process

The processes that treat the products from arrival from the field are summarized in the following steps:

a) Raw material Reception /Weighing

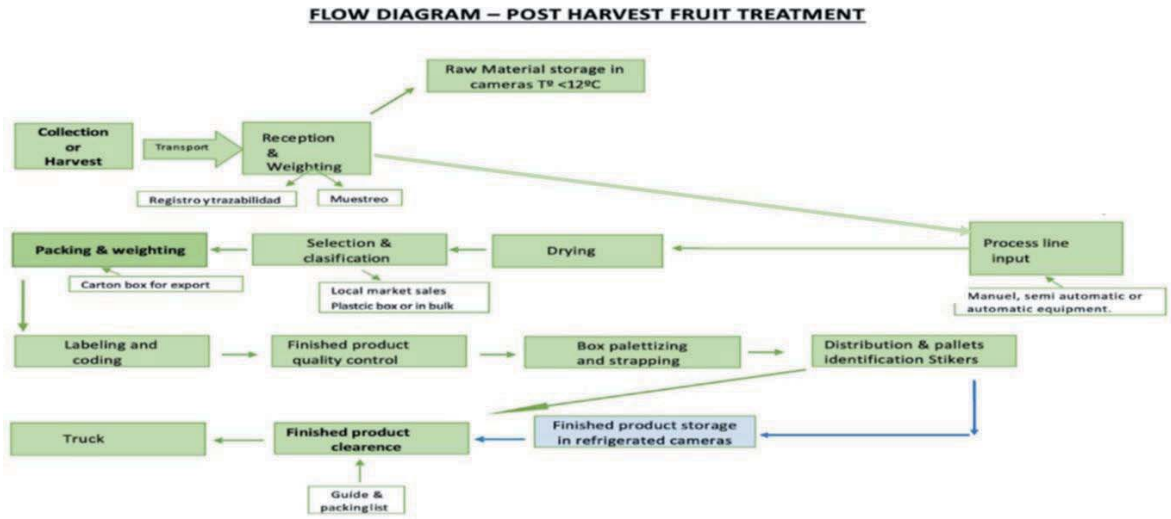
b) First Selection (Culling)

c) Dry cleaning

d) Selection and Classification (Grading)

e) Labelling, Packaging and Weighing

f) Finished Product Shipping or Storage in Cold Rooms



Okras must be protected from exposure to direct sunlight while they wait for transport to the packinghouse. On most farms, the fruit may wait from 30 minutes to 2 hours maximum before they are transported to the packinghouse. Therefore, direct sunlight exposure must be avoided since it results in sunburn and higher flesh temperatures, which in turn accelerates ripening and shortens potential shelf life.

Okras can either be offloaded to the packinghouse in field crates or from trucks with large cargo holds. Upon arrival at the packinghouse, Okras is placed on a wider and smooth, food grade type, belt conveyor for cleaning grading and packing by weight and size in accordance with buyer standards and/or requirements. Grading allows for the removal of Okras that are misshaped, bruised, cut, or have signs of decay. Okras are packed into ventilated, single-layer cartons with or without lids. The openings in the cartons are used for ventilation and are important to ensure uniform temperature and humidity during storage and shipping.

9.6 Transportation to Packing House Tips

- Containers should be well stacked to avoid any movement.
- Vehicles must always be covered or insulated.
- Vehicles must be cushioned.
- Fruits must be protected from dust, sun and rain.

9.7 Sorting, Cleaning & Grading Tips

- Sorting to remove diseased, mis-shaped, damaged, and unripe fruits and foreign matter.
- Cleaning with a clean cloth
- Grading according to size (count), colour, and texture

9.8 Packing Tips

- For the export market, pack Okra in bulk in fibreboard cartons of 5.3 kg and 10.3 kg weight.
- The cartons should be well ventilated.
- After packing the Okra is palletized if requested by the buyer and then placed in a cold storage room at a temperature 7°C -10°C (45°F -50°F).

Pre-cooling or quick cooling inside the cold storage room to slow down the metabolic processes is highly recommended and will extend shelf life. This is done using a forced air tunnel type cooler that forces the cold air of the room through the packed fruit until the fruits quickly cool down to room temperature.

9.9 Packing House Sanitation

Fresh produce such as Okra can be contaminated with pathogens and other harmful agents when the packing house is not thoroughly clean and sanitized, especially surfaces that come in direct contact with the produce. Cleaning agents such as bleach in a 5% solution are used to scrub surfaces clean, including those that remain wet during the packing process. The cleaning and sanitizing process includes four steps:

- Surfaces should be rinsed so any obvious dirt and debris are removed.
- Apply an appropriate detergent and scrub the surface.
- Rinse the surface with water that is the microbial equivalent of drinking water (potable).
- Apply an appropriate sanitizer. If the sanitizer requires a final rinse, this will require an extra step. Let the surface air dry.

Access to the packing house must be restricted to personnel involved in the packing operation. Other people and animals are not allowed inside. Packing personnel must wear appropriate protective clothing and head gear and must maintain good hygiene and health.

The packing shed must be protected from rainfall and wind-borne contamination such as dust. The surrounding areas must be treated if necessary to avoid any type of contamination.

Figure 17: Packaging House Sanitation

9.10 Storage Tips

- Storage temperature 7°C -10°C (45°F -50°F)
- Okra is sensitive to chilling injury. There is impaired ripening resulting in poor colour and flavour development at low temperature below 7 °C.
- Relative Humidity should be maintained at between 95 % – 100 %).

10. Export Protocol

10.1 Okra Shipping Reefer Containers

Okras are shipped in reefer containers (refrigerated). These containers provide refrigeration to protect the quality and prolong the shelf life of the produce. The quantity of 5 kg Okra boxes that can be shipped depends on the type of reefer and the configuration of the cargo:

	Normal Reefer			High Cube Reefer		
Reefer	**Pallets**	**Boxes**	**BB Bxs**	**Pallets**	**Boxes**	**BB Bxs**
20-Ft	10	700	840	10	770	924
40-Ft	20	1,400	1,680	20	1,540	1,848

BB = Break Bulk

Pallet configuration is 7 x 10 for a normal reefer and 7 x 11 for a High Cube reefer. Configuration of the cargo in break bulk shipping varies a great deal. Reefer containers will take a few more boxes in a break bulk configuration, but most clients prefer palletized Okra. There is usually an upfront charge for palletized fruit to offset the cost.

The temperature for holding and shipping Okra ranges from 7°C -10°C (45°F -50°F) under normal atmosphere conditions. Controlled atmosphere shipping is not recommended for Okra.

The ventilation setting for a reefer container should be set at 25% (97 m^3/hr to 116 m^3/hr) for short trips such as from Sri Lanka to the Middle East and 15% (56 m^3/hr to 67 m^3/hr) for longer trips.

Containers must be thoroughly checked for damage and operational readiness before loading. In addition, they must be pre-cooled and completely scrubbed clean and sanitized with a 5% bleach solution, or similar, to receive the cargo. It is important to make sure they remain in optimum condition and free from foreign invaders such as insects all throughout the loading process.

Figure 18: Reefer Container

Figure 19: Reefer Container Settings Panel

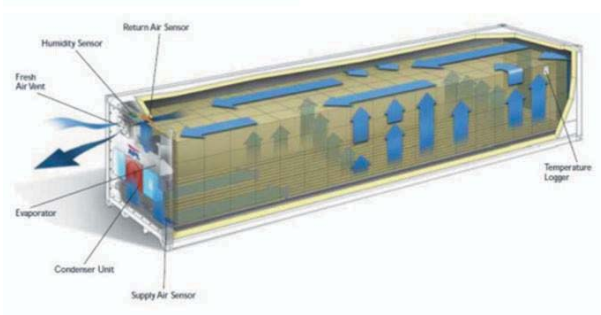


Figure 20: Reefer Container Cool Air Flow

Figure 21: Temperature Monitoring Device

Figure 22: Loading Okra in Reefer Container

11. Cost Benefit Analysis

Item	Unit	Without project	With Project
Fresh Production /HA	MT		
Okra		20	120
Production Waste	%	20	20
Sales Volume/HA	MT		
Okra		16	96
Cost/Kg	LKR		
Okra		35.5	49.21
Selling Price/Kg	LKR		
Okra		120	230
Item	**Unit**	**Without project**	**With Project**
Gross Income/ HA	LKR Mn		
Okra		1.92	22
Gross Margin/ HA	LKR Mn		
Okra		1.36	17.28
Av. Monthly Income			
Okra		225,440	3,023,919
Benefit/Cost Ratio			
Okra		**3.3**	**5**

Table 8: Farmer Level Cost Benefit Analysis[4]

[4] The public domain information from gardeners and commercial plantings around the world gives a range for pod weight and number of pods per plant, the two primary productivity parameters, as follows:

Pod weight: 28 to 56 grams

Number of pods per plant: 10 to 50.

With a population of 56,000 plants per hectare and 80% marketable yield, the following table shows the potential productivity of okra in metric tons per hectare:

	No. of Pods/Plt	
Pod Weight, g	10	50
28	12.5	62.7
56	25.1	125.4

This table show a range of potential yield from 12.5 mt/Ha to 125 mt/Ha.

Is worth noting that in Florida in the US, population densities for Okra range from 37,000 to 217,000 plants per hectare (Crop Profile for Okra in Florida, June 2005, https://ipmdata.ipmcenters.org/documents/cropprofiles/FLokra.pdf)
This is really an example of the planting density revolution happening around the world. The ISP wants to make sure Sri Lanka benefits from this high technical approach to horticulture.
In terms of the Cost Analysis in the ISP Okra Operational Manual, the potential yield per hectare was estimated using maximum pod weight and maximum number of pods per plant. A simple sensitivity analysis can show what is the cost-benefit at different yield levels.

ANNEX1: FERTIGATION PROTOCOL

Management of the Irrigation System

1. Turn irrigation pump on and allow the operating pressure of the system to become stable at the correct operating pressure (1 Bar to 2 Bar).

2. When pressure is stable, make sure venturi system is working correctly using only water in the fertigation tank or container.

3. Once venturi system is checked, proceed to fertigate with the fertilizer solution.

4. After fertigation, allow the system to continue to apply irrigation water to the plot for at least 10 minutes in order to flush out any fertilizer solution residue remaining in the system.

5. Make sure to apply Phosphoric acid every two weeks as recommended to make sure system remains unclogged by deposits of calcium salts.

Using Fertigation Solutions

1. Carefully follow "*Irrigation and Fertigation Recommendations"* issued by the ISP to make sure the right amounts and types of fertilizer materials are used for fertigation.

2. To prepare the fertigation solution, accurately weigh the correct amounts of fertilizer materials using a portable weighing scale.

3. Mix the weighed fertilizer material with water in an appropriate container such as a 20-litre plastic bucket using a clean wooden stick to stir the fertilizer material into the water to make sure all the fertilizer material is dissolved.

4. In case there is a fertilizer material that is not 100% soluble in water such as TSP, mix for at least 5 minutes to dissolve as much material as possible.

5. Filter the fertigation solution into the fertigation container to be used with the venturi system (fertigation tank or container) using a cloth filter such as an old t-shirt or similar.

6. After filtering, the fertilizer material left on the cloth filter when using a partially soluble fertilizer material such as TSP must be saved into a container to be used in the next fertigation with the same material.

7. Close the main valve of the irrigation system and open the valves of the venturi system to force the irrigation water to flow through the venturi system. This will create the necessary vacuum to suck the fertigation solution into the irrigation system to be distributed throughout the plot and applied to the crop.

8. After the fertigation solution is applied, add clean water to the fertigation container and allow this water to flow though the venturi system to clean it.

9. Open the main valve and close the venturi system valves to allow for normal irrigation to resume.

ANNEX 2: SOIL ANALYSIS RESULTS AND FERTILIZER RECOMMENDATIONS

Analitical Report on Soil
Vegetable Cluster - Polonnaruwa

Sample Code	Lab No	pH	OM	EC	Ca	Mg	K	NH4-N	P	S	Cu	Fe	Mn	Zn	CEC	Ca/Mg	Ca/K	Mg/K	Ca+Mag/K	Ca Sat.
		1:2.5, H2O	%	µs/cm	Exchangeable (meq/100g)			Available (ppm)							cmol/kg	Cation Ratios				
M. G. A. Kumarasiri	B3 471	6.41	2.02	64.7	6.7	2.53	0.51	46.6	36	15	9.1	320	5.6	4.4	9.9	2.6	13.1	5.0	18.1	67.7
T. P. G. D. T. Amarasekara	B4 471	6.47	2.29	83.9	10.29	2.24	1.06	51.9	191	21	12.4	246	5.5	13.9	13.8	4.6	9.7	2.1	11.8	74.6
U. W. P. Chamara	B5 471	6.62	2.82	115.8	8.63	1.47	1.04	124.1	94	24	9.6	190	6.1	6	11.1	5.9	8.3	1.4	9.7	77.7
A.G. Wasanthi Jayamin	B6 471	6.45	1.61	43.3	7.89	1.94	1.4	46.3	273	24	10.5	980	18.03	6.3	11.4	4.1	5.6	1.4	7.0	69.2
P. A. Oskara Ruwan Sagara	B7 471	6.38	2.55	90.6	11.79	3.64	0.7	58.5	31	21	8.1	732	18.5	3.3	16.3	3.2	16.8	5.2	22.0	72.3
W. M. Subarathna Bandara	B8 471	6.32	1.88	141.9	7.39	2.16	1.68	86.6	49	22	6.4	682	14.8	10.1	11.4	3.4	4.4	1.3	5.7	64.8
E. M. Roshan Tharuka Ekanayaka	B9 471	6.78	2.42	131.9	13.66	2.39	0.76	27.8	34	35	13	234	3.4	1.9	16.8	5.7	18.0	3.1	21.1	81.3
S. A. A. S. Siriwardana	B10 471	6.83	1.88	95.1	10.09	1.86	1.32	92.2	14	13	11	158	4.7	8.9	13.3	5.4	7.6	1.4	9.1	75.9
D. R. M. Indumal Ashoka	R1 472	6.81	2.29	86.5	7.76	2.17	1.72	43.9	41	38	10.7	156	3.7	6.1	11.7	3.6	4.5	1.3	5.8	66.3
W. G. Anurasiri	R2 472	6.91	1.21	33	10.21	3.09	0.58	43.2	27	25	7.1	480	11.8	13.3	13.9	3.3	17.6	5.3	22.9	73.5

Interpretation:

Organic matter low in about 40% of the samples
Potassium Low also in 49% of the samples
Soluble Nitrogen low
Sulphur, Manganese and Zinc low
The Cation ratios are low
The Calcium saturation is high

Fertilizer Recommendations:

Nitrogen as required by the crop
Potassium as MOP
Sulphur as MgSO4
Foliar applications of micronutrients
Mostly Manganese and Zinc

Kg/ Plot/ Application	Initial	Mid	Late
Urea	0.95	0.98	0.92
MOP	1.0	1.1	1.0
$MgSO_4$	2.5	2.6	2.4
Application per week	2		
Phosphoric Acid (ml) *Application every two week*	68.2	70.3	66

Table 9: Fertigation recommendations per application per plot