කෘෂිකර්ම, පශු සම්පත්, ඉඩම් හා වාරිමාර්ග අමාත්‍යාංශය
கமத்தொழில், கால்நடை, வளங்கள், காணி மற்றும் நீர்ப்பாசன அமைச்சு
MINISTRY OF AGRICULTURE, LIVESTOCK, LANDS AND IRRIGATION

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

Funded by
The European Union

ASMP
කෘෂි අංශ නවීකරණ ව්‍යාපෘතිය
விவசாய நவீன நவீனமயமாக்கல் திட்டம்
Agriculture Sector Modernization Project

OPERATIONAL MANUAL

BRINJAL

AGRICULTURE SECTOR MODERNIZATION PROJECT

PARK
AGRICULTURE TECHNOLOGY DEMONSTRATION PARK

Prepared by -
Dr. Julian Velez - International Agronomist
FCG New Zealand (FCG ANZDEC Ltd.)

This publication was funded by the World Bank and European Union. Its contents are the sole responsibility of Agriculture Sector Modernization Project implemented under the Ministry of Agriculture Livestock, Lands and Irrigation and do not necessarily reflect the views of the World Bank or European Union.

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 6
1.1 Optimal Ecological Requirements 6
2. LAND PREPARATION 7
2.1 Primary Land Preparation 7
2.2 Secondary Land Preparation 7
2.3 Tractor 7
2.4 Drainage 7
3. VARIETIES 8
4. PLANTING MATERIAL 9
5. HIGH DENSITY PLANTING 10
5.1 Procedure 10
5.2 Plant Spacings Within the Crop Rows 11
5.3 Planting Aids 11
6. IRRIGATION AND FERTIGATION 12
6.1 Irrigation 12
6.2 New Irrigation Concepts 12
6.3 Water Application 12
6.4 Fertigation 12
7. WEED CONTROL 16
8. PEST AND DISEASE CONTROL 17
8.1 Peripheral Insect Net 17
8.2 Yellow Sticky Traps 18
8.3 Most Common Pests and Diseases in Brinjal in Sri Lanka 19
9. HARVESTING 21
9.1 Maturity Indexes 21
9.2 Harvesting Procedures 22
10. POST-HARVEST HANDLING 22
10.1 Brinjal Post Harvest Profile 22
10.2 Packing Procedures for Export 25
10.3 Packing Centre Layout 26
10.4 Packing Process 26
10.5 Transportation to Packing House Tips 27
10.6 Sorting, Cleaning & Grading Tips 27
10.7 Packing Tips 27
10.8 Packing House Sanitation 27
10.9 Storage Tips 28
11. Export Protocol 28
11.1 Brinjal Shipping Reefer Containers 28
12. Cost Benefit Analysis 30

ANNEX1: FERTIGATION PROTOCOL 30
ANNEX 2: SOIL ANALYSIS RESULTS AND FERTILIZER RECOMMENDATIONS 32

Table 1: Cocopel Disks Specifications 10
Table 2: Irrigation Schedule 12
Table 3: Nutrition Quantities 14
Table 4: Quantities of fertilizer materials per year (season) 14
Table 5: Quantities of fertilizer as per stage of development 14
Table 6: Week-wise, fertilizer quantities 15
Table 7: Fertilizer quantities, as per application basis (irrigation cycle) 15
Table 8: Fertigation Recommendation per Application per Plot 15
Table 9: Farmer Level Cost Benefit Analysis 30
Table 10: Fertigation Recommendations per Application per plot 32

Figure 1: Thinnaweli Purple Brinjal 8
Figure 2: Pusa Purple Long Brinjal 8
Figure 3: Black Beauty Brinjal 9
Figure 4: Green Long Brinjal 9
Figure 5: Brinjal Seedlings Transplanting 9
Figure 6: Cocopel Germination and Growth Disks 10
Figure 7: Bed Preparation 10
Figure 8: Drip Tape Installation 10
Figure 9: Mulching 11
Figure 10: Micro-Sprinkler System 12
Figure 11: Advantages of low-pressure irrigation 12
Figure 12: Yellow Sticky Traps 18
Figure 13: Yellow Sticky Traps in Field 19
Figure 14: Fruit and Shoot Borer 19
Figure 15: Aphids (Aphidoidea) 19
Figure 16: Whiteflies (Bemisia tabaci) 20
Figure 17: Early Blight (Alternaria solani) 20
Figure 18: Bacterial Wilt (Ralstonia solanacearum) 20
Figure 19: Fusarium Wilt (Fusarium oxysporum) 21
Figure 20: Packaging Centre Layout 26
Figure 21: Packaging House Sanitation 28
Figure 22: Reefer Container 29
Figure 23: Reefer Container Settings Panel 29
Figure 24: Reefer Container Cool Air Flow 29
Figure 25: Temperature Monitoring Device 29
Figure 26: Loading Brinjals in Reefer Container 29

1. INTRODUCTION

Brinjal or Eggplant, also known as Aubergine *(Solanum melongena),* belongs to the Solanaceae family, which includes several economically important species such as tomatoes, potatoes, and peppers. The plant's origins trace back to the Indian Subcontinent, where it was first domesticated. The wild forms of Brinjal can still be found in regions of India and Bangladesh.

From these South Asian origins, Brinjal cultivation spread to China and Southeast Asia, where it was extensively grown as early as 500 B.C. The plant was later introduced to Africa and Europe through the Arab expansion in the 7th century. The Moors brought the Brinjal to Spain in the 8th century, and its cultivation gradually spread throughout the Mediterranean region, mainly in Italy and Greece. Brinjals were initially met with skepticism in Europe due to the belief that they were related to the mandrake, a plant associated with superstition and folklore.

The Brinjal was introduced to the Americas by explorers and colonists in the 18th century. Today, it is grown worldwide for its edible fruit and is a common ingredient in a variety of international cuisines.

Brinjal is a perennial plant, often grown annually. It grows typically between 40 and 150 cm (16 and 59 in) tall. The stem is often spiny, and the leaves are large, coarsely lobed, and semi-alternate with a length of 10 to 20 cm (4–8 in) and a width of 5 to 10 cm (2–4 in). They are covered with soft, small hairs which can produce irritation on the skin.

Flowers are usually solitary and located in the axils of the leaves. They are white to purple in color, with a five-lobed tubular corolla and yellow stamens. Some varieties produce flowers with a singular color, while others may exhibit a combination of white and purple.

The fruit of the Brinjal is fleshy and has a meaty texture. Botanically, it's classified as a berry and contains numerous small, soft seeds. The shape and color of the fruit vary greatly among different varieties. The most common type is the large, dark purple, pear-shaped fruit. But there are also elongated and spherical types, and colors can range from black and various shades of purple to white, yellow, and green.

1.1 Optimal Ecological Requirements

Brinjals are warm season crops that require a long growing season. They thrive best in a hot climate and are sensitive to frost. The optimum temperature for growth and development is between 21-30 °C (70-85 °F). Temperatures below 13 °C (55 °F) can damage the plant and slow growth, while temperatures above 35 °C (95 °F) can cause flowers to drop and reduce yield.

The optimum rainfall for growing Brinjals depends on various factors, including the specific variety of Brinjal, prevailing climate conditions, and the stage of growth. Generally, Brinjals thrive in warm and moderately humid environments. Adequate rainfall is crucial for their growth and development, but excessive moisture can lead to various problems such as root rot or fungal diseases. As a general guideline, Brinjals require an average of 1.65 (4.2 cm) of water per week. However, this can vary depending on the soil type and drainage capabilities. It's important to monitor the moisture levels in the soil and adjust watering accordingly. Additionally, providing a well-draining soil and mulching around the plants can help retain moisture and prevent waterlogging.

Although Brinjals are moderately drought-tolerant, their growth and yield significantly decline under water stress conditions. For this reason, irrigation is crucial in dry areas or during prolonged dry spells.

Brinjals are sun-loving plants and require full sun exposure for optimal growth and productivity. They should receive at least 6 hours of direct sunlight each day.

In terms of soil requirements, Brinjals prefer well-drained soil with ample organic matter. Sandy loam or clay loam soils are ideal. The soil should have a pH between 5.5 and 6.5.

2. LAND PREPARATION

2.1 Primary Land Preparation

1. Deep ploughing using a 60 cm diameter disk plough.
2. Incorporation of organic matter (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[1]

2.4 Drainage

Drainage is of particular importance for the Brinjal 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 Brinjal.

1. **Light Texture Soils:**
   Light textured soils are preferred for the cultivation of the Brinjal.
   - 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 Brinjal 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 Brinjal 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

[1] It is unfortunate that Sri Lankan farmers do not have access to bigger tractors. It is recommended to procure modern machineries for Sri Lankan farmers, which can enable more efficient land preparation. ISP also recommends procuring moldboard plough to turn the soil over.

3. VARIETIES[2]

Brinjal cultivation in Sri Lanka encompasses a diverse range of varieties, each offering unique characteristics, flavors, and culinary benefits.

a) Thinnaweli Purple

Thinnaweli Purple, with its vibrant color, firm texture, and excellent taste, stands out as a native variety that captures the essence of Sri Lankan cuisine. It is a distinct Brinjal variety that is native to Sri Lanka. This variety is primarily cultivated in the dry zone regions of the country, including Anuradhapura, Polonnaruwa, and Puttalam.

Figure 1: Thinnaweli Purple Brinjal

Key Features of Thinnaweli Purple

a) Appearance: The Thinnaweli Purple Brinjal has an elongated shape with smooth and glossy purple skin, adding an appealing visual element to dishes.
b) Size: It typically grows to a medium size, ranging from 10 to 15 centimeters in length, making it suitable for various culinary preparations.
c) Texture: The flesh of Thinnaweli Purple is firm and creamy, allowing it to retain its shape and texture when cooked, whether stir-fried, roasted, or grilled.
d) Taste: Thinnaweli Purple Brinjals have a slightly sweet and mild flavor that adds depth and complexity to dishes.
e) Cooking Applications: Due to its firm texture and pleasant taste, Thinnaweli Purple Brinjals are well-suited for curries, stir-fries, stews, and roasting. It blends harmoniously with spices and other ingredients, making it a versatile choice for Sri Lankan cuisine.

In addition to Thinnaweli Purple, Sri Lanka cultivates several other Brinjal varieties, each with its distinct characteristics and culinary uses. Some notable varieties include the following:

b) Pusa Purple Long

Pusa Purple Long Brinjals feature long, slender fruits with a glossy purple skin. They are favored for their adaptability to different climatic conditions and high yield. These Brinjals are suitable for various cooking methods, including frying, grilling, and stuffing.

Figure 2: Pusa Purple Long Brinjal

[2] DoA: Currently only Thinnaweli purple has been recommended as a DoA recommended variety. Other varieties in this manual are not recommended or introduced by DoA.

ISP: The variety was chosen to satisfy the demands from the international market for a medium size Brinjal, solid deep purple in color. Other varieties were mentioned just for contrast and general information. The main variety attributes according to the international market are medium size and solid deep purple color. DoA should approve the import of new varieties

c) Black Beauty

Figure 3: Black Beauty Brinjal

Black Beauty Brinjals have a round to oval shape with a deep purple or black-colored skin. They are widely grown in Sri Lanka and are popular for their rich flavor and versatility in cooking. Black Beauty Brinjals are used in curries, stews, dips, and even as a stuffing for dishes such as Brinjal rolls.

Figure 4: Green Long Brinjal

d) Green Long

Green Long Brinjals have a slender shape with light green skin. They are commonly used in Sri Lankan cuisine for making pickles, curries, and stir-fries. These Brinjals have a slightly bitter taste when raw but mellow out and develop a unique flavor when cooked.

Whether it is Thinnaweli Purple, Pusa Purple Long, Black Beauty, or Green Long, Brinjals continue to be a popular and versatile vegetable in Sri Lankan cooking, elevating the flavors of traditional dishes and adding a touch of culinary creativity.

The Black Beauty variety was chosen to satisfy the demands from the international market for a medium size Brinjal, oval and solid deep purple in color.

4. PLANTING MATERIAL

Brinjal seedlings for transplant are grown in an elevated nursery stand 0.9 m high, 0.75 m to 1 m wide and as long as required, provided there is enough space in a protected place near the farmer's house or similar for protection against animals and other and near a good water source. The nursery stand has a clear thick plastic ceiling (higher than 50 microns). It is also a good idea to protect the nursery stand with an insect net to minimize insect damage. In addition, the nursery should be covered with a shade net (50% light penetration) at least for a period of 10 days and then gradually opened and exposed to full sunlight at least one week before transplanting.

Figure 5: Brinjal Seedlings Transplanting

Cocopell, a compressed growth pellet disk produced using high quality treated coconut coir fiber pith, originating from renewable and organic raw materials. The "Cocopel Grow Pellet" comes with added fertilizer and is wrapped around the pellet with a bottom sealed bio-degradable net. The net is certified by the EU.

The pellets are expanded to nursery size containers by adding moisture. Then the Brinjal seeds are sowed one at a time in the expanded pellet. The seedlings need to grow for at least 28 to 42 days to reach a height of 15 cm. They are ready for transplanting (field ready) at the specified

Feature	32mm pellet	38mm pellet	42mm pellet
Diameter (mm)	32	38	42
Initial height (mm)	6 - 7	10 - 12	13 - 15
Expansion height (mm)	26 - 34	36 - 42	40 - 45
Dry weight (g)	3 - 3.5	5.5 - 6	6.5 - 7.5
Absorbing water amount (ml)	21 - 29	38 - 40	52 - 60
Water holding capacity (%)	70 - 75	70 - 75	70 - 75

height and having developed true leaves, in addition to being free from pests and diseases. At this stage, the seedlings should have a sturdy stem and a healthy root system.

Porosity (%)	19 - 25	19 - 25	19 - 25
Wetting time (minutes)	2	2	2
Electrical conductivity	0.09 - 0.1 (S/m)	0.09 - 0.1 (S/m)	0.09 - 0.1 (S/m)
PH	5.5 - 6.5	5.5 - 6.5	5.5 - 6.5
Suitable for	Tomato, basil, coriander, flowers, pepper, small plant cuttings	cucurbits, sweet pepper, lettuces, comparatively large seeds	Ornamental plant cuttings, tissue cultural plants

Table 1: Cocopel Disks Specifications

The fertilizer content of the pellet is supplemented once per week with foliar applications of fertilizers containing micronutrients until the seedlings are field ready.

After sowing and for the growing period in the elevated nursery stand (approximately 30 days), the pellet containers are placed on plastic trays designed to support a good number of the expanded pellets (at least 50 cells per tray).

Figure 6: Cocopel Germination and Growth Disks

5. HIGH DENSITY PLANTING

Thinnaweli Purple Brinjals are typically grown from seedlings, in nurseries. Direct seeding in the field is practiced as well, but seedlings are preferred.

5.1 Procedure

The Brinjal 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 Brinjal 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 7: Bed Preparation

Figure 8: 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.

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.

Figure 9: 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.[3]

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.

5.2 Plant Spacings Within the Crop Rows[4]

Brinjal	0.40 m

5.3 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

[3] The ISP recommends poly mulch as part of a package to prevent soil borne diseases. In this package, land preparation is very important to obtain small soil aggregates with high surface area that promotes internal drainage and better nutrient uptake. The height of the planting bed of 0.5 m complements the land preparation practice in creating an ideal physical environment for the growth of the root system of the plant, free from excess water. The height of the bed and the drainage ditch that borders the planting bed create the necessary physical forces that allow for the quick evacuation of excess water from the soil surrounding the roots,keeping them well aerated and free from soil borne diseases. The poly mulch protects the planting bed from excess rainfall entering the soil profileto cause water logging conditions and at the same time reduces evapotranspiration, controlsthe growth of weeds and makes the drip tape more durable and efficient

[4] According to DoA, this is not in accordance with recommendation of DoA. As per ISP, this is the new technology introduced by the ISP for ASMP farmers. Is a different planting pattern from the DOA recommendation, with different plant spacings in a triangular arrangement, suitable for high density horticulture, an ISP initiative to comply with the ISP mandate to introduce modern technology not used in farmers' fields in Sri Lanka

6. IRRIGATION AND FERTIGATION

6.1 Irrigation

Brinjal 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 10: Micro-Sprinkler System

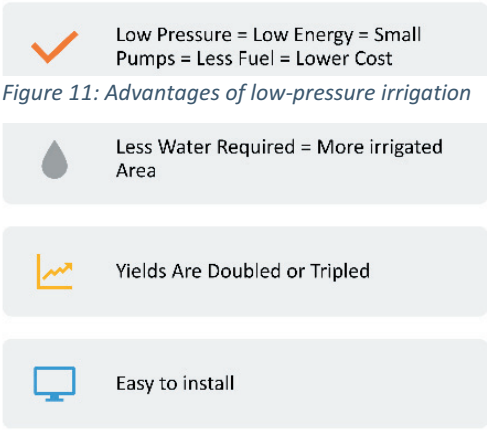


Figure 11: Advantages of low-pressure irrigation

6.2 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)

6.3 Water Application

The Brinjal 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 Brinjal 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 2: Irrigation Schedule

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

6.4 Fertigation

Brinjal (*Solanum melongena*) is a widely cultivated vegetable crop known for its culinary versatility and nutritional value. To achieve optimum yields and high-quality produce, a balanced supply of macronutrients (nitrogen, phosphorus, potassium) and essential micronutrients is required.

a) Nitrogen (N)

Nitrogen is a crucial nutrient for Brinjal plants as it plays a vital role in vegetative growth, leaf development, and overall plant vigor. Adequate nitrogen supply promotes the formation of healthy foliage, which is essential for maximizing photosynthesis and subsequent fruit production. Apply nitrogen-based fertilizers such as urea, ammonium nitrate, or organic sources like compost or well-rotted manure. Split the nitrogen application, with the initial dose at planting and subsequent doses during the growing season to meet the plant's increasing demand.

b) Phosphorus (P)

Phosphorus is vital for root development, flowering, and fruit set in Brinjal plants. Adequate phosphorus supply promotes strong root systems, early flowering, and improved fruit quality. Incorporate phosphorus-rich fertilizers such as superphosphate or bone meal into the soil before planting. Alternatively, apply phosphorus-based fertilizers as a side dressing during the early growth stages.

c) Potassium (K)

Potassium is essential for overall plant health, disease resistance, and fruit development in Brinjal. It promotes strong stems, improves water and nutrient uptake, and enhances the quality of fruits. Apply potassium-rich fertilizers such as potassium sulfate or potassium chloride. Split the potassium application into multiple doses, starting from the early growth stage until fruiting, to ensure continuous availability of this nutrient.

d) Calcium (Ca)

Calcium is essential for cell wall development, preventing disorders like blossom-end rot in Brinjal fruits. Adequate calcium supply ensures proper fruit development and reduces the risk of quality issues. Apply calcium sources such as gypsum or calcium nitrate to the soil before planting or as a foliar spray during the growing season.

e) Magnesium (Mg)[5]

Magnesium is a critical component of chlorophyll, the pigment responsible for photosynthesis. It is necessary for energy production and overall plant growth. Magnesium deficiency can lead to yellowing of leaves and reduced yields. Apply magnesium sulfate or dolomitic lime if magnesium deficiency symptoms are observed.

f) Micronutrients

Brinjal plants also require various micronutrients for optimal growth and development. These include iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), boron (B), and molybdenum (Mo). While these micronutrients are required in small quantities, their deficiencies can significantly impact plant growth and productivity. Conduct a soil test to assess micronutrient levels and apply suitable fertilizers or foliar sprays to address any deficiencies.

Regular monitoring of nutrient levels, soil testing, and adjusting fertilization practices accordingly will help maintain healthy Brinjal plants and maximize yields.

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 Brinjal 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

[5] 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.

However, Mg deficiency symptoms have been encountered in several ASMP Clusters and have been corrected by amending the soil with fertilizer grade $MgSO_4$

The Cation ratios are low. Of concern is the narrow Mg/K ratio. Mg as a soil amendment is needed
The Calcium saturation is high. The soil amendment with Mg will reduce the Ca saturation as well

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

Nitrogen as required by the crop
Potassium as MOP
$MgSO_4$ [6]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 3: 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 4: 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 5: Quantities of fertilizer as per stage of development

[6] Magnesium is not recommended as a nutrient. 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. Only 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 the fertilizer grade MgSO4 is only 10%, a large application of the fertilizer material is required to supply the soil the small amount of the Mg^{2+} ion required as a soil amendment.

Considering an Brinjal 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 6: 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 7: Fertilizer quantities, as per application basis (irrigation cycle)

These amounts are further reduced based on the net area cultivated in Brinjal. 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 8: Fertigation Recommendation per Application per Plot

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

7. 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.

8. PEST AND DISEASE CONTROL

IPM concepts and practices must be applied to manage Brinjal 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

8.1 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 Brinjal 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 crop 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.

8.2 Yellow Sticky Traps

Figure 12: 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 13: Yellow Sticky Traps in Field

For Brinjal, 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.

8.3 Most Common Pests and Diseases in Brinjal in Sri Lanka

a) Fruit and Shoot Borer (*Leucinodes orbonalis*)

The fruit and shoot borer are one of the most destructive pests of Brinjal. The adult moths lay eggs on the leaves, and the larvae bore into the shoots and fruits, causing extensive damage. The life cycle of the fruit and shoot borer is completed in about 25-30 days. The larvae tunnel inside the fruits, leading to premature dropping and rotting.

Control Measures:

- Remove and destroy infested shoots and fruits.
- Install pheromone traps to monitor and trap adult moths.
- Apply biological control agents like Trichogramma wasps, which parasitize the eggs of the fruit and shoot borer.
- When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Figure 14: Fruit and Shoot Borer

b) Aphids *(Aphidoidea)*

Aphids are small, soft-bodied insects that feed on the tender parts of Brinjal plants. They suck the sap, causing curling and stunting of leaves, and excrete honeydew, promoting the growth of sooty mold. Aphids reproduce rapidly, and their populations can build up quickly under favorable conditions.

Control Measures:

- Spray a strong jet of water to dislodge aphids from the plants.
- Introduce natural predators like ladybugs, lacewings, or parasitic wasps to control aphid populations.
- Apply insecticidal soaps or neem oil as organic alternatives.
- In severe infestations, use insecticides.
- When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Figure 15: Aphids (Aphidoidea)

c) Whiteflies *(Bemisia tabaci)*

Whiteflies are tiny, winged insects that cluster on the undersides of Brinjal leaves. They suck sap and cause yellowing, wilting, and distortion of leaves. Excessive whitefly feeding can lead to the development of sooty mold on the honeydew they produce.

Figure 16: Whiteflies (Bemisia tabaci)

Control Measures:

- Use yellow sticky traps to monitor and trap adult whiteflies.
- Encourage natural enemies like parasitic wasps and predatory beetles.
- Apply insecticidal soaps, neem oil, or horticultural oils as organic control options.
- When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.
- Insect growth regulators can be used as chemical control measures, following the recommended rates.

d) Early Blight *(Alternaria solani)*

Early blight is a fungal disease that affects Brinjal leaves, stems, and fruits. It is characterized by the appearance of dark brown lesions with concentric rings on the leaves. The disease can cause defoliation, reduced yield, and poor fruit quality.

Figure 17: Early Blight (Alternaria solani)

Control Measures:

- Practice crop rotation to reduce disease pressure.
- Avoid overhead irrigation to minimize leaf wetness.
- Remove and destroy infected plant debris.
- Apply fungicides containing chlorothalonil, mancozeb, or copper-based compounds at recommended rates.
- When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

e) Bacterial Wilt *(Ralstonia solanacearum)*

Bacterial wilt is a devastating disease that affects Brinjal plants. It causes wilting, yellowing, and eventual death of the plant. The bacteria can persist in the soil for a long time, making it difficult to control.

Figure 18: Bacterial Wilt (Ralstonia solanacearum)

Control Measures:

- Plant disease-resistant varieties when available.
- Practice crop rotation with non-solanaceous crops.
- Use pathogen-free seeds or seedlings.
- Soil solarization can help reduce bacterial populations.
- There are no effective chemical control measures for bacterial wilt.

f) Fusarium Wilt *(Fusarium oxysporum)*

Fusarium wilt is a fungal disease that affects the vascular system of Brinjal plants. It causes yellowing, wilting, and stunting of the plant. The fungus can survive in the soil for several years.

Figure 19: Fusarium Wilt (Fusarium oxysporum)

Control Measures:

- Plant resistant varieties whenever possible.
- Practice crop rotation to reduce disease pressure.
- Use pathogen-free seeds or seedlings.
- Avoid over-irrigation and waterlogging.
- Soil fumigation with appropriate chemicals such as Neem oil drench can be considered in severe cases.
- When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Soil fungal and bacterial diseases are caused by fungi and bacteria that thrive in conditions of excess water within the soil profile. To prevent these diseases, a preventive IPM strategy is utilized that integrates recommended land preparation and poly mulching technical practices. The land preparation practices are very important to create small soil aggregates with high surface area that promotes internal drainage and better nutrient uptake. The height of the planting bed of 0.5 m increases internal drainage and complements the land preparation practice in creating an ideal physical environment in the soil profile for the growth of the root system of the plant, free from excess water. The height of the bed and the drainage ditch that borders the planting bed create the necessary physical forces that allow for the quick evacuation of excess water from the soil surrounding the roots, keeping them well aerated and free from soil borne diseases. The poly mulch protects the planting bed from excess rainfall entering the soil profile to cause water logging conditions and at the same time reduces evapotranspiration, controls the growth of weeds and makes the drip tape more durable and efficient.

9. HARVESTING

9.1 Maturity Indexes

To ensure the optimal harvest of Brinjal, farmers rely on various maturity indexes that indicate the ideal stage for harvesting the crop:

a) One commonly used index is the fruit color. As Brinjal matures, the color of the fruit undergoes a transformation, providing a visual cue for farmers. When the Brinjal fruit reaches its mature stage, it exhibits a glossy and deep color, depending on the variety. The coloration may vary from shades of purple to green, depending on the specific cultivar. For example, the classic purple Brinjal varieties should have a rich, dark purple color when fully mature, while the green Brinjal varieties will develop a vibrant, glossy green hue.

b) In addition to color, farmers also consider the fruit size and firmness as indicators of maturity. Brinjal fruit grows in size as it matures, and farmers often have an ideal size in mind for each variety. Harvesting the fruit at this specific size ensures optimal flavor and texture. The size may vary depending on the variety and the market demand. For instance, some varieties are preferred for their smaller-sized fruit, while others are known for their larger, more robust fruit.

c) Furthermore, the firmness of the fruit is an important factor when determining its maturity. Brinjal that is too soft may be overripe and past its prime, while fruit that is too firm may be underripe and lacking in flavor. The fruit should be gently pressed to assess its firmness. A mature Brinjal should have a slight give when pressed, indicating that it is ripe and ready for harvest.

By carefully monitoring these maturity indexes, Brinjal can be harvested at the optimal time, resulting in superior quality and flavor. Harvesting too early may result in a lack of sweetness and a more bitter taste. On the other hand, delaying the harvest may lead to a loss in flavor and a tougher texture. It is important for farmers to strike the right balance and harvest the Brinjal at the peak of its maturity to maximize its taste, texture, and nutritional value.

9.2 Harvesting Procedures

Harvesting Brinjal for export requires careful handling and adherence to quality standards to ensure that the produce reaches its destination in optimal condition:

a) **Timing:** Harvesting should be done at the right stage of maturity to ensure the Brinjal is at its peak quality. The ideal time for harvesting varies depending on the variety, but generally, the fruit should be glossy, firm, and have reached full color. Avoid harvesting overripe or underripe Brinjals.
b) **Preparation:** Before harvesting, gather the necessary tools and equipment such as sharp pruning shears or a knife, gloves, and harvest crates or boxes. Ensure that the containers are clean and free from any contaminants.
c) **Field Inspection:** Walk through the Brinjal field and visually inspect the plants. Look for mature fruits that meet the quality standards for export. Select Brinjals that are uniform in size, have a smooth skin surface, and are free from blemishes, cuts, or bruises.
d) **Harvesting Technique:** Use a sharp knife or pruning shears to cut the Brinjal fruit from the stem. Make a clean, smooth cut, leaving a short stem attached to the fruit. Avoid pulling or twisting the fruit, as this may cause damage. Handle the Brinjal carefully to prevent any bruising or injury.

The delivery of high-quality produce to international markets is assured by following the proper harvest procedures listed above. Exporters must remember to stay updated with the specific requirements and regulations of the target export markets to ensure compliance with food safety and high-quality norms and maximize customer satisfaction.

10. POST-HARVEST HANDLING

10.1 Brinjal Post Harvest Profile

Maturity Indices

Brinjals are harvested at a range of developmental stages. Depending on cultivar and temperature, the time from flowering to harvest may be 10 to 40 days. Generally, crop is harvested immature before seeds begin to significantly enlarge and harden. Firmness and external glossiness are also indicators of a pre-maturity condition. Brinjal become pithy and bitter as they reach an overmature condition.

Quality Indices

The diversity of Brinjal types being marketed has increased greatly in recent years. Standard Brinjal quality is primarily based on uniform egg to globular shape, firmness, and a dark purple skin color. Additional quality indices are size, freedom from growth or handling defects, freedom from decay, and a fresh green calyx.

Other Brinjal types include:

- Japanese - elongated, slender, light to dark purple, very perishable.
- White - small egg shaped to globular, thin skinned
- Mini-Japanese - small elongate, striated purple and violet
- Chinese - elongated, slender, light purple

United States Department of Agriculture Brinjal Grades

To ensure quality and consistency, the United States Department of Agriculture (USDA) has established grading standards for fresh produce, including Brinjal. These standards provide guidelines for growers, distributors, and consumers to evaluate and classify Brinjals based on their quality characteristics, including size.

Three grades for eggplants exported to the US have been defined by the USDA: U.S. Fancy, U.S. No. 1, and U.S. No. 2. Each grade represents a specific level of quality and appearance. Let's explore the net weight and count specifications for each grade:

1. U.S. Fancy:

   i. U.S. Fancy Brinjals are the highest quality grade, characterized by their superior appearance, shape, and color. They are free from defects that affect their overall marketability.

   ii. Size Specifications: U.S. Fancy Brinjals should have a minimum diameter of 1 1/4 inches (31.8 mm) and a minimum length of 2 3/4 inches (69.9 mm). The diameter is measured at the widest part of the vegetable.

   iii. Standard Net Weight: The standard net weight for U.S. Fancy eggplants per fiber box is typically between 24 and 30 pounds (10.9 to 13.6 kilograms).

   iv. Count: The standard count for U.S. Fancy eggplants per fiber box is typically 12 to 15 eggplants.

2. U.S. No. 1:

   i. U.S. No. 1 Brinjals represent a slightly lower grade compared to U.S. Fancy but still maintain good quality and appearance. They may have slight defects that do not significantly impact their marketability.

   ii. Size Specifications: U.S. No. 1 Brinjals should have a minimum diameter of 1 inch (25.4 mm) and a minimum length of 2 1/2 inches (63.5 mm).

   iii. Standard Net Weight: The standard net weight for U.S. No. 1 eggplants per fiber box is typically between 24 and 30 pounds (10.9 to 13.6 kilograms).

   iv. Count: The standard count for U.S. No. 1 eggplants per fiber box is typically 12 to 15 eggplants.

3. U.S. No. 2:

   i. U.S. No. 2 Brinjals are the lowest grade and may exhibit more noticeable defects in terms of appearance, shape, or color. While they may have cosmetic imperfections, they are still suitable for consumption.

   ii. Size Specifications: U.S. No. 2 Brinjals should have a minimum diameter of 3/4 inch (19.1 mm) and a minimum length of 2 inches (50.8 mm).

   iii. Standard Net Weight: The standard net weight for U.S. No. 2 eggplants per fiber box is typically between 24 and 30 pounds (10.9 to 13.6 kilograms).

   iv. Count: The standard count for U.S. No. 2 eggplants per fiber box is typically 12 to 15 eggplants.

4. Additional Considerations:

In addition to size specifications, the USDA grading standards for fresh Brinjal also consider other factors such as color, shape, freedom from defects, and overall quality. The sizes mentioned above

provide a guideline for the minimum acceptable dimensions but do not limit the maximum size of the Brinjals within each grade. It is worth noting that Brinjals may vary in size and shape due to natural factors and varietal differences.

5. Benefits of USDA Grades:

The USDA grades for fresh Brinjal offer several benefits to different stakeholders within the industry:

- Growers: By adhering to USDA grading standards, growers can ensure that their Brinjals meet the quality criteria demanded by the market. This can result in increased marketability, higher prices, and improved customer satisfaction.
- Distributors: Distributors can use the USDA grades to select Brinjals that meet the specific requirements of their customers. This helps in maintaining consistency in the supply chain and reducing potential disputes regarding quality.
- Consumers: The USDA grades serve as a reliable indicator of Brinjal quality for consumers. By choosing Brinjals with higher grades, consumers can expect superior taste, texture, and overall satisfaction with their purchase.
- In addition, the USDA grades for fresh Brinjal play a crucial role in ensuring consistent quality and appearance in the market. The three grades, U.S. Fancy, U.S. No. 1, and U.S. No. 2, provide a framework for evaluating Brinjals based on their size and other quality attributes. By adhering to these standards, growers, distributors, and consumers can make informed decisions regarding the selection and purchase of fresh Brinjals.

Optimum Temperature

10-12°C (50-54°F)

Storage

Storage of Brinjal is generally less than 14 days as visual and sensory qualities deteriorate rapidly. Decay is likely to increase following storage beyond two weeks, especially after removal to typical retail conditions. Short term storage or transit temperatures below this range are used often to reduce weight loss but will result in chilling injury after several days.

Chilling Injury

Brinjal fruit are chilling sensitive at temperatures below 10°C (50°F). At 5°C (41°F) chilling injury will occur in 6-8 days. Consequences of chilling injury are pitting, surface bronzing, and browning of seeds and pulp tissue. Accelerated decay by *Alternaria* spp. is common in chilling stressed fruit. Chilling injury is cumulative and may be initiated in the field prior to harvest.

Optimum Relative Humidity

90-95% R.H.

Rates of Ethylene Production

0.1-0.7 µl/kg·hr at 12.5°C (55°F)

Responses to Ethylene

Brinjal has a moderate to high sensitivity to exogenous ethylene. Calyx abscission and increased deterioration, particularly browning, may be a problem if Brinjals are exposed to >1ppm ethylene during distribution and short-term storage.

10.2 Packing Procedures for Export

a) **Sorting and Selection:** Choose Brinjals that are fresh, firm, and free from any damage or blemishes. Sort the harvested Brinjals based on their size, shape, and quality. Remove any damaged, diseased, or undersized fruits. Grade the Brinjals according to the export standards, which may include specific size and weight requirements.

b) **Cleaning:** Gently wipe off any dirt or debris from the Brinjals using a soft cloth or brush. Avoid using water unless necessary, as excess moisture can promote spoilage during transportation.

c) **Grading:** Grade the Brinjals based on their size and quality according to buyer requirements. This step helps in standardizing the packing process and ensures uniformity in the final packaging.

d) **Packaging Materials:** The most common packaging material used for exporting Brinjals is fiberboard boxes. These boxes are sturdy, lightweight, and provide adequate protection during transportation. The size of the fiberboard box may vary, but commonly used dimensions are 40 cm x 30 cm x 20 cm (length x width x height).

e) **Preparing the Fiberboard Boxes:** Assemble the fiberboard boxes and ensure they are clean, dry, and free from any contaminants. Reinforce the corners and edges of the boxes with tape to provide additional strength.

f) **Cushioning Material:** Line the bottom of the fiberboard boxes with a layer of cushioning material such as straw, shredded paper, or foam pads. This helps absorb and prevents damage to the Brinjals.

g) **Arranging Brinjals:** Place the Brinjals in a single layer inside the box, ensuring they are not overcrowded. This prevents bruising and maintains the quality of the produce. It is advisable to place Brinjals in a staggered manner to minimize gaps and movement during transit.

h) **Separation and Layering**: Separate each layer of Brinjals with a thin layer of cushioning material. This prevents direct contact between the Brinjals and provides additional support. Repeat this process until the box is filled, ensuring that the top layer is level and even.

i) **Secure the Box:** Close the fiberboard box securely and reinforce the seams with strong packaging tape. Label the boxes with necessary information such as the product name, quantity, country of origin, and any handling instructions.

j) **Net Weight:** The net weight of the Brinjal packaging may vary depending on export regulations and market requirements. Typically, Brinjals are packed in boxes weighing around 5 to 10 kilograms. However, it is essential to check the specific weight requirements of the destination country.

k) **Quality Control:** Perform a final inspection to ensure the packaging is intact, the Brinjals are properly arranged, and there are no signs of damage or spoilage. Remove any damaged or overripe Brinjals from the packaging.

l) **Storage and Transportation:** Store the packed Brinjals in a cool, well-ventilated area with proper temperature and humidity control. During transportation, it is crucial to minimize exposure to extreme temperatures and avoid stacking heavy objects on top of the boxes to prevent damage.

m) **Export Documentation:** Prepare and complete all necessary export documentation, including phytosanitary certificates, customs forms, and invoices. Ensure compliance with the import regulations and requirements of the destination country.

n) **Quality Control:** Regularly inspect the Brinjals during storage and transportation to identify any signs of decay, mold, or other quality issues. Remove any damaged or deteriorated fruits to prevent them from affecting the overall quality of the batch.

10.3 Packing Centre Layout

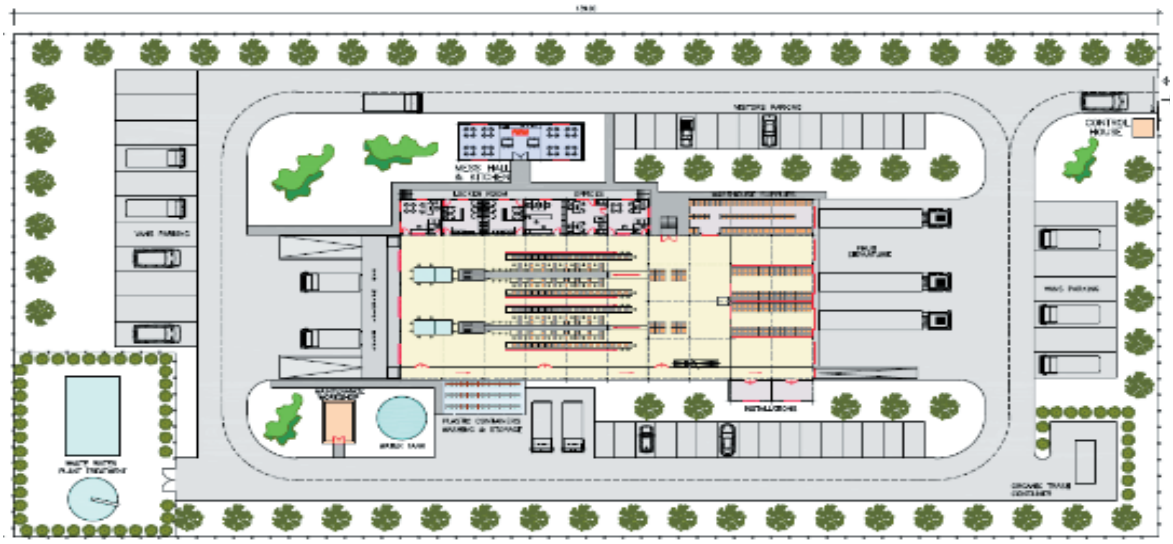


Figure 20: Packaging Centre Layout

10.4 Packing Process

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

a) Raw material Reception /Weighing

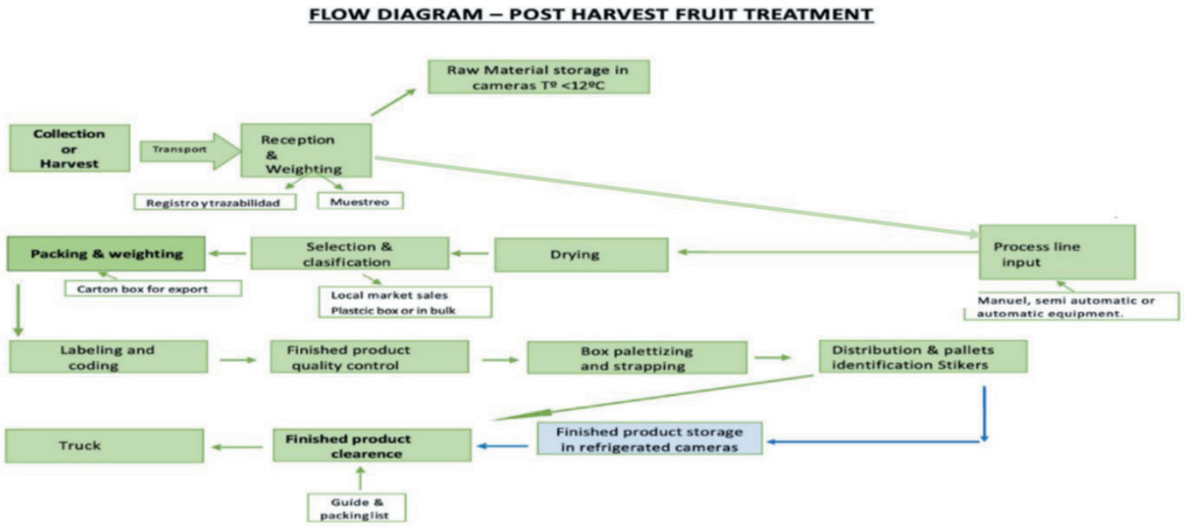
b) First Selection (Culling)

c) Dry cleaning

d) Selection and Classification (Grading)

e) Labelling, Packaging and Weighing

f) Finished Product Shipping or Storage in Cold Rooms



Brinjals 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.

Brinjals can either be offloaded to the packinghouse in field crates or from trucks with large cargo holds. Upon arrival at the packinghouse, Brinjals 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 Brinjals that are misshaped, bruised, cut, or have signs of decay. Brinjals 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.

10.5 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.
- Crop must be protected from dust, sun and rain.

10.6 Sorting, Cleaning & Grading Tips

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

10.7 Packing Tips

- For the export market, pack Brinjal in brinjal in fibreboard cartons of 5.3 kg and 10.3 kg weight.
- The cartons should be well ventilated.
- After packing the brinjal is palletized if requested by the buyer and then placed in a cold storage room at a temperature 10°C -12°C (50°F -54°F) with a relative humidity of 90% to 95%.

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.

10.8 Packing House Sanitation

Fresh produce such as Brinjal 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 21: Packaging House Sanitation

10.9 Storage Tips

- Storage temperature 10°C -12°C (50°F -54°F).
- Brinjal is sensitive to chilling injury. There is impaired ripening resulting in poor colour and flavour development at low temperature below 10 °C.
- Relative Humidity should be maintained at between 90 % – 97 %.

11. Export Protocol

11.1 Brinjal Shipping Reefer Containers

Brinjals 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 Brinjal 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 Brinjal. There is usually an upfront charge for palletized fruit to offset the cost.

The temperature for holding and shipping Brinjal ranges from 10°C -12°C (50°F -54°F) under normal atmosphere conditions. Controlled atmosphere shipping is not recommended for Brinjal.

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 22: Reefer Container

Figure 23: Reefer Container Settings Panel

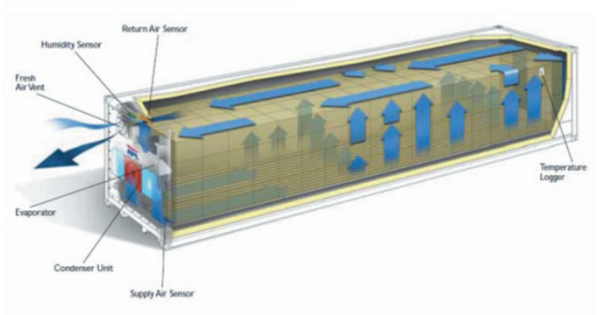


Figure 24: Reefer Container Cool Air Flow

Figure 25: Temperature Monitoring Device

Figure 26: Loading Brinjals in Reefer Container

12. Cost Benefit Analysis

Table 9: Farmer Level Cost Benefit Analysis

Item	Unit	Without project	With Project
Fresh Production /HA Brinjal	MT	22	90
Production Waste	%	20	20
Sales Volume/HA Brinjal	MT	17.6	72
Cost/Kg Brinjal	LKR	34.7	63.74
Selling Price/Kg Brinjal	LKR	150	320
Item	**Unit**	**Without project**	**With Project**
Gross Income/ HA Brinjal	LKR Mn	2.6	23
Gross Margin/ HA Brinjal	LKR Mn	2	18.42
Av. Monthly Income Brinjal		338,167	3,075,170
Benefit/Cost Ratio Brinjal		**3.4**	**5.6**

The potential yield per hectare for Brinjal of 90 mt under high density planting can be constructed as follows:

Number of Brinjals per plant	Units	5
Average weight of a Brinjal	Grams	400
Population density	Plants/Ha	56,000
Potential gross yield per hectare	MT/Ha	112.5
Marketable fraction of gross yield	Percent	80
Potential Marketable yield per hectare	Mt/Ha	90

On average, a single eggplant plant can produce between 4 to 6 eggplants per harvest, although this number can vary depending on factors such as the variety of eggplant, growing conditions, and care given to the plant. The average weight of an eggplant typically ranges from 200 to 400 grams, but larger varieties can weigh up to 1 kilogram or more. These figures are based on general observations and agricultural studies on eggplant cultivation. Proper care and optimal growing conditions can help maximize the yield and size of eggplants produced per plant.

Reference:

- University of California Agriculture & Natural Resources. (n.d.). Eggplant. https://ucanr.edu/sites/gardenweb/files/290877.pdf

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 10: Fertigation Recommendations per Application per plot