TECHNICAL OPERATIONAL MANUAL

CAPSICUM

AGRICULTURAL SECTOR MODERNIZATION PROJECT (ASMP)

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INTRODUCTION

Capsicum, commonly known as peppers, originates from the Americas, specifically Central and South America. The genus Capsicum includes a variety of species, with the most well-known being Capsicum annuum (Peppers and jalapeños), Capsicum chinense (habaneros), and Capsicum frutescens (tabasco peppers).

Capsicum species were cultivated by indigenous peoples for thousands of years before the arrival of Europeans in the Americas. Archaeological evidence suggests that Capsicum was domesticated in areas such as Mexico and northern South America around 5000 to 6000 years ago. After the Columbian Exchange in the 15th and 16th centuries, Capsicum spread to Europe, Africa, and Asia, where it became a staple in many cuisines worldwide.

The heat and flavor of Capsicum peppers are primarily due to the compound capsaicin, which has various culinary and medicinal uses. Today, Capsicum is grown in many regions around the globe, making it one of the most widely cultivated and consumed plants.

Optimal Ecological Requirements

To optimize capsicum production, several ecological, climatic, and soil conditions should be considered:

Ecological Conditions

1. Location: Capsicum thrives in warm climates, typically found in subtropical and tropical regions.
2. Biodiversity: A diverse ecosystem can help control pests and diseases, enhancing capsicum growth.

Climatic Conditions

1. Temperature: Ideal daytime temperatures range from 20°C to 30°C (68°F to 86°F). Night temperatures should not drop below 15°C (59°F) to avoid stress.
2. Sunlight: Capsicum requires full sun exposure, ideally 6 to 8 hours of direct sunlight daily.
3. Humidity: Moderate humidity levels (around 60-70%) are beneficial, as excessive humidity can lead to fungal diseases.
4. Rainfall: Regular and well-distributed rainfall (around 600-800 mm per year) is important, with good drainage to prevent waterlogging.

Soil Conditions

1. Soil Type: Well-drained, loamy soils are ideal. Sandy loam or clay loam can also support good drainage and nutrient retention.
2. pH Level: A slightly acidic to neutral pH (6.0 to 7.0) is optimal for nutrient availability.
3. Nutrient Content: Rich in organic matter with adequate levels of nitrogen, phosphorus, and potassium. Soil testing can help determine necessary amendments.
4. 4.Drainage: Good drainage is crucial to prevent root rot and other water-related issues.

LAND PREPARATION

Primary Land Preparation

1. Deep ploughing using a disk or mouldboard plough as large as possible, from 30 cm to 60 cm (12" to 24") in diameter.
2. Incorporation organic matter, commercial compost (12 MT per hectare or 5 MT per acre) and other soil amendments as required by broadcasting all over the plot surface.
3. Deep plough again perpendicular to the first pass.

Secondary Land Preparation

1. Heavy Soil Textures
   a. Disk harrow using a disk harrow implement with disks having a diameter from 18 cm to 24 cm (7" to 10").
   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.

Tractor

1. A tractor size 75 to 99 HP (75 to 85 POT), four-wheel drive, is best to pull large ploughing equipment.

Drainage

Drainage is of particular importance for the Capsicum as the crop is susceptible to several root diseases. Good internal drainage provided by raised beds (30 cm to 50 cm high) and a network of drainage ditches to quickly evacuate high amounts of rainfall are very important practices to prevent Fusarium Wilt, Phytophthora root rot and other soil borne diseases affecting Capsicum.

Evacuation Drainage

For small plots, a “U” type evacuation drainage design is recommended. This system is made up of two lateral drainage ditches (collectors) at the extreme ends of the plot that drain into a primary drainage canal (evacuator) that evacuates the water away from the plot into a safe area, avoiding damage to property or goods. All drainage ditches must be trapezoidal in shape to avoid the collapse of the walls into the ditch and subsequent loss of depth by sedimentation. Grass or small plants can be promoted on the walls of the ditches to keep them stable. The size of the laterals and evacuator should be as shown below:

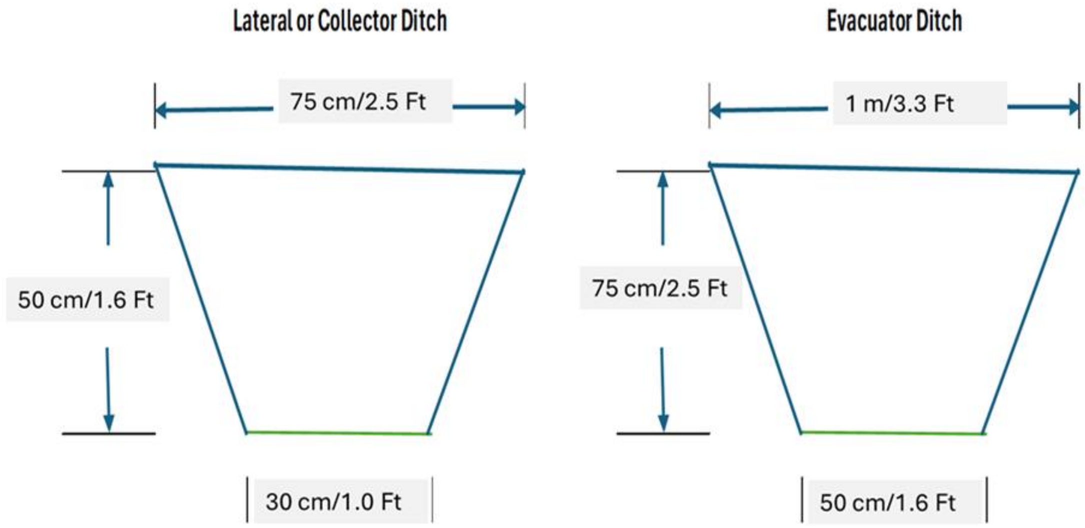


Figure 1: Size of Drainage Ditches

All ditches must have a slope or gradient of at least 0.1% which is equivalent to a drop of 1 m in 1,000 m. This slope is also expressed as 0.001

This on-farm simple drainage system can evacuate 4 mm of rain per hour or 96 mm per day. Catastrophic conditions such as flooding can occur with rainfall greater than 100 mm per day. These conditions will cause damage to crops and can only be mitigated with macro drainage work done by the Government.

Before making the ditches, it is necessary to observe the slope of the plot. It is recommended to place the large evacuator ditch cutting across the terrain and along the lowest section of the plot. Then, the lateral ditches are placed perpendicular to the evacuator. The planting beds should drain into the laterals or collectors, which, in turn, drain into the large evacuator

If necessary, for crops that are planted in the East-West direction such as the double row planting of fruit trees, the laterals can be made to cut across the double rows to force them to drain into the large evacuator placed along the lowest section of the plot.

Surface Drainage

After a heavy rain, wet spots often remain in different locations, especially if the field has not been levelled or does not have a slope gradient sufficient to force the water out of the plot by gravity. In these cases, it is recommended for the farmers to drain all the wet spots by manually guiding the water out of each spot into a nearby drainage ditch or canal using a hoe type tool. Two or more wet spots can be connected to be finally drained into a drainage ditch or canal.

Figure 2: Draining Wet Spots Using Surface Drainage

VARIETIES

In Sri Lanka, the most common varieties and hybrids of capsicum include:

1. Local Varieties: Traditional varieties such as 'Kankun' and 'Mihiranga' are popular for their adaptability to local climates and soil conditions.
2. Hybrid Varieties: Hybrids like 'California Wonder' and 'Yolo Wonder' are frequently cultivated for their high yield, disease resistance, and better marketability.
3. Colored Varieties: Red, yellow, and green Peppers are commonly grown, with red varieties often preferred for their sweetness and nutritional value.
4. Disease-Resistant Hybrids: Hybrids that are resistant to common diseases like bacterial wilt and powdery mildew are increasingly favored by farmers to ensure better crop health and yield.

PLANTING MATERIAL

Capsicum 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

Figure 4: Elevated Nursery

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
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

Figure 3: Cocopel Specifications

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 gauge).

Cocopel, a compressed growth pellet disk produced using high quality treated coconut coir fiber pith, originates 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 Capsicum seeds are sowed one at a time in the expanded pellet. The seedlings need to grow for at least 30 days to reach a height of 12 cm – 15 cm. They are ready for transplanting (field ready) at the specified height and have 5 to 6 well developed leaves, in addition to being free from pests and diseases.

Figure 5: Cocopel Disks and Growth Container

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.

HIGH DENSITY PLANTING

Procedure

The Capsicum is planted in beds made by mechanical bed-makers pulled by tractors. They can also be made by hand. The beds should be 60 cm wide and 30 cm to 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.

After making the beds, one drip tape line is installed in the middle of the bed for irrigation purposes. 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 1.5 Bar to 2.0 Bar of pressure. The drip tape is followed by a silver and black plastic mulch with a thickness (gauge) of 30 microns to 40 microns and a width of 5 ft (1.52 meters). The mulch is placed on top of the planting beds.

Figure 6: Planting Pattern and Spacing

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. This combination is one of the most efficient and productive systems for maximizing both yield and irrigation efficiency.

Figure 7: Planting Beds and Drip Tape

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 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 the 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.

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.

Plant Spacings Within the Crop Rows

Capsicum	0.40 m
Population Density per Half Acre	11,311

Planting Aids

1. Construction twine (preferably white coloured)

2. A good number of wooden stakes to layout base lines and crop rows
3. Previously made planting templates
4. Measuring tape
5. Markers

IRRIGATION AND FERTIGATION

Irrigation

Capsicum 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 system, water is applied drop by drop or by micro jet (micro sprinkler), on the soil surface or below it (sub-surface), at a rate lower than the infiltration of the soil.

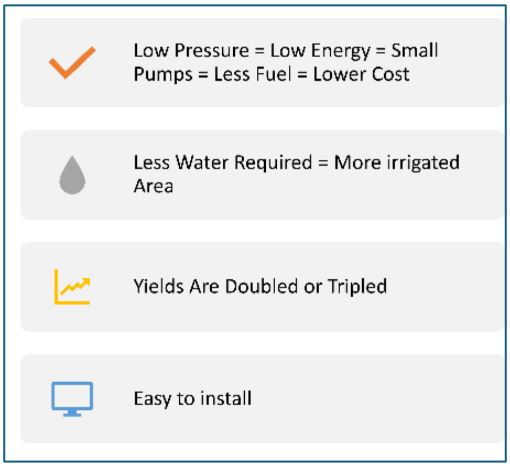


Figure 8: Advantages of Low-Pressure Irrigation

Figure 9: Drip Tape for Irrigation

<u>New Irrigation Concepts</u>

- 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)

Water Requirements

Capsicum (bell pepper) plants typically require about 6 mm of water per day, depending on factors like growth stage, temperature, and humidity. During hot weather or when the plants are fruiting, their water needs may increase. It is crucial to maintain the soil moisture level at Field Capacity to promote healthy growth and fruit development.

The water requirements of Capsicum (bell pepper) can vary significantly at different stages of phenological development:

1. Germination (0-2 weeks):
   a. Water Requirement: Approximately 2-4 mm/day
   b. Notes: Consistent moisture is critical for seed germination. Soil should be kept moist but not waterlogged (Field Capacity).

2. Seedling Stage (2-4 weeks):
   a. Water Requirement: Around 3-5 mm/day
   b. Notes: Young plants are sensitive to moisture stress. Adequate watering encourages healthy root development.

3. Vegetative Stage (4-8 weeks):
   a. Water Requirement: Approximately 5-6 mm/day
   b. Notes: As plants grow, their water needs increase. Regular watering is essential to support leaf and stem development.

4. Flowering Stage (8-10 weeks):
   a. Water Requirement: About 5-7 mm/day
   b. Notes: Consistent moisture is vital during flowering to ensure good fruit set. Stress can lead to flower drop.

5. Fruit Development (10-14 weeks):
   a. Water Requirement: Approximately 6-8 mm/day
   b. Notes: Water uptake is crucial during fruit development for optimal size and quality. Irregular watering can affect fruit quality.

6. Maturation (14 weeks onwards):
   a. Water Requirement: About 5-6 mm/day
   b. Notes: As fruits ripen, consistent moisture is still important, but slightly reduced watering can be beneficial before harvest to enhance flavour.

Water Application

Low pressure irrigation systems are designed to keep the soil moisture level at field capacity which is the optimal soil moisture level for root growth and development. At this level, the soil provides ample and sufficient amounts of Oxygen and water to the roots of the different crops.

At constant field capacity soil moisture, the amount of water to be applied through irrigation is the water loss by evapotranspiration, adjusted for rainfall. In other words, low pressure irrigation must provide the amount of water necessary to cover the water deficit of the crop on a daily basis to prevent the crop from suffering from water stress and losing yield potential. Modern weather stations provide evapotranspiration rates on a daily basis for farmers to properly irrigate their crops. To facilitate this modern technology process, ASMP has installed mini weather stations in 21 Clusters in different Districts of the Country.

Figure 10: Mini Weather Station

In the absence of weather station data, the amount of water to be applied is based on the consumptive water use of the crop. As a minimum, and on a daily basis, crops must receive the amount of water required for optimum growth, development and yield, defined as consumptive water use. The Capsicum consumptive water use is defined as 6 mm/Day in this manual.

Based on this concept, the water use amount by the plant is adjusted further using the FAO Kc factors or crop irrigation coefficients that consider the phenological development of the Tomato plant, including canopy and root development,

	Vegetative	**Flowering**	**Pod Dvlmt**
Kc Factor or Crop Coefficient, FAO	0.5	0.7	1.0

This daily amount can be accumulated on a weekly basis and applied in two cycles of irrigation per week. As an illustration, the chart below shows the recommended irrigation times per cycle to deliver the weekly adjusted consumptive water use of Capsicum using the drip tape irrigation system.

Table 1: Irrigation Time for Capsicum Based on Consumptive Water Use

Irrigation Schedule	initial		Development		Production	
Irrigation Time (Hours/Minutes)	0	48	1	6	1	25

Recommended irrigation Times Should Be Adjusted Further to Allow for Larger/Deeper Wetting Front

However, it is important to note that crops may need more water than the consumptive water use on a daily basis to prevent water stress and loss of yield potential brought about by water deficits that are determined by evapotranspiration, rainfall, etc. On a practical basis, and for the sake of simplicity, more water should be applied on very hot and dry days and less on cloudy and rainy days, and the weather stations can tell us exactly how much to apply.

Fertigation

Nutritional Requirements

To ensure optimal growth and fruit production, Capsicum should be provided with a balanced supply of macronutrients and micronutrients throughout its growth cycle. Regular soil testing can help in adjusting nutrient applications based on the specific needs of the plants and the existing soil conditions.

Capsicum has specific nutritional requirements to support healthy growth, flowering, and fruiting. Here's a detailed overview of its nutritional needs:

Macronutrients

1.Nitrogen (N):
- Role: Vital for vegetative growth, leaf development, and overall plant vigor.
- Source: Can be supplied through fertilizers like ammonium nitrate or urea, as well as organic options such as compost or manure.

2.Phosphorus (P):
- Role: Crucial for root development, energy transfer, and flowering. It promotes strong root systems and enhances fruit set.
- Source: Bone meal, rock phosphate, or high-P fertilizers (e.g., 10-20-10).

3.Potassium (K):
- Role: Important for fruit quality, disease resistance, and water regulation. Potassium helps improve fruit size and flavor.
- Source: Potassium sulfate or muriate of potash, as well as organic sources like kelp meal.

Secondary Nutrients

1. Calcium (Ca):
   - Role: Essential for cell wall structure and preventing blossom end rot in fruits.
   - Source: Lime, gypsum, or calcium-rich fertilizers.
2. Magnesium (Mg):
   - Role: Important for photosynthesis and overall plant metabolism.
   - Source: Epsom salts (magnesium sulfate) or dolomitic lime.
3. Sulfur (S):
   - Role: Necessary for protein synthesis and enzyme function.
   - Source: Sulfate fertilizers or organic amendments like compost.

Micronutrients

Capsicum also requires small amounts of various micronutrients for optimal growth:

- Iron (Fe): Important for chlorophyll synthesis.
- Manganese (Mn): Aids in photosynthesis and enzyme function.
- Zinc (Zn): Essential for growth hormone production and leaf development.
- Copper (Cu): Plays a role in photosynthesis and respiration.
- Boron (B): Important for flower and fruit development.

Soil Considerations

- pH Level: Capsicum prefers a slightly acidic to neutral pH (6.0 to 7.0). Soil pH affects nutrient availability; for example, iron becomes less available in alkaline soils.
- Organic Matter: Incorporating organic matter improves soil structure, nutrient retention, and microbial activity, enhancing nutrient availability.

<u>Fertigation Recommendations</u>

For the Capsicum in the Vegetables Cluster in Badulla, 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.

Table 2: Interpretation of the Soil Test

Low Mg in two sites
Low K in two sites
Low S in 4 sites
Cu, Mn and Zn generally low
Narrow Cation Ratios
Low Ca Saturation

The results for the soil test for the Vegetable Cluster in Badulla indicated the following:

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

Table 3: Fertilizer Recommendations Bases on the Soil Test

Urea as required by the crop
CaCO3 lime at land preparation
MOP in two sites
MgSO4
Foliar Micronutrients as T-Flush

Based on the above considerations, the recommended amounts of nutrients to be applied through fertigation in the sites with low Potassium are shown in elemental and oxide form below:

Recommendation	N	K	Mg
Kg/Ha	150.0	150.0	50.0
Lb/acre	150.0	150.0	50.0
Kg/Acre	68.2	68.2	22.7

Phosphoric Acid P (Kg/Ha)	20.0

Recommendation	Urea	K20	MgO
Kg/Ha	326.1	343.7	82.9
Lb/acre	326.1	343.7	82.9
Kg/Acre	148.2	156.2	37.7

The Phosphoric Acid is recommended to prevent the physical and chemical clogging of the irrigation system.

The elemental quantities of nutrients need to be converted to fertilizer materials to make up the fertigation recommendation for the whole cropping season in Kg/Acre:

Kg/Acre	Urea	MOP	P Acid	MgSO4

Fertilizer per Season	322	260	33	227

Each of these amounts of fertilizer materials is then adjusted according to the phenological development of the crop. The FAO Irrigation Crop Coefficients (Kc) for Capsicum are used for this purpose:

Parameter	Initial	Development	Production
Kc	0.40	0.80	1.10

This means the crop will receive 40% of the recommended amounts of fertilizer during the initial stages of physiological development, 80% during the development or active growth phase and 1.10% during the production phase.

These amounts of fertilizers are then distributed on a per week basis according to the duration of each phenological stage of the crop cycle. These calculations result in amounts of fertilizer materials per Acre and per week (Kg/acre/Week):

Crop Cycle	Initial	Development	Production
Weeks	4	9	4

Kg/Acre/Week	Initial	Development	Production
Urea	30.07	30.07	82.70
MOP	24.30	24.30	66.82
MgSO4	21.21	21.21	58.33
P Acid	3.05	3.05	3.05

Phosphoric Acid is kept constant because is not used as a fertilizer material

The weekly amounts of fertilizers are then converted to amounts per application using 2 applications per week:

Applications per Week	2

Kg/Acre/Application	Initial	Development	Production
Urea	15.037	15.037	41.352
MOP	12.149	12.149	33.410
MgSO4	10.606	10.606	29.167
P Acid	1.525	1.525	1.52

Finally, the amounts per Acre per application are adjusted to the size of the net production area of the plot which for the ASMP Project is half an Acre (50 m x 40 m):

Bed Width (m)	Bed Length (m)	Bed Net Area (m2)	Number of Beds	Plot Net Area (Acres)
0.6	40	24	56.6	0.34

In other words, in a production area of 0.5 Acre, only 0.34 Acres will be receiving fertilizer as follows:

Plot/Application	Unit	Initial	Development	Production
Urea	Kg	5.10	5.10	14.03
MOP	Kg	4.12	4.12	11.34
$MgSO_4$	Kg	3.60	3.60	9.90
Applications per Week	2			
Phosphoric Acid (ml)	Ml	307.2	307.2	307.2
Application every two weeks				

The fertigation recommendation is complemented by the recommended application of other required fertilizer materials as indicated below:

Apply Calcium in the form of $CaCO_3$ at a rate of 200 Kg/Half Acre during land preparation
Foliar Applications of Micronutrients (T-Flush 100 ml/16 L) Are also Recommended weekly. Very important

WEED CONTROL

Weeds are controlled using agricultural type silver and black plastic with a thickness (gauge) of 30 microns to 40 microns and a width of 5 ft (1.52 meters). Agricultural plastic mulch 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.

PEST AND DISEASE MANAGEMENT

IPM concepts and practices must be applied to manage Capsicum 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

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

Peripheral Insect Net

Figure 11: Peripheral 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 Capsicum 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-foot 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.
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.

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.

Figure 13: Yellow Sticky Traps in the Field

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.

For Capsicum, 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 those involved in the “Curled Leaf Virus Complex”.

Aflatoxin Contamination

Aflatoxins are a family of naturally occurring mycotoxins produced by fungi in the genus Aspergillus. These fungi live naturally in soil, as well as in dead and decaying plant material in fields. Aflatoxins are highly carcinogenic and mutagenic, having the ability to cause liver cancer, damage the immune system and decrease growth and productivity in both humans and livestock. These toxins are found all over the world. In hot and humid agricultural regions there can be a serious loss to the value of crops from aflatoxin contamination.

Aflatoxins are regularly found in improperly stored staple commodities such as Capsicum peppers, cassava, maize, cotton seed, millet, peanuts, rice, sesame seed, sorghum, sunflower seed, tree nuts, wheat, and a variety of spices. When contaminated food is processed, aflatoxins enter the general food supply where they contaminate both human and livestock foods. Animals fed contaminated food can pass aflatoxin transformation products into eggs, milk products, and meat.

Most strains of *Aspergillus parasiticus* can produce the group of four mycotoxins: B1, B2, G1, and G2, while *Aspergillus flavus* usually only produces B1 and B2. Aflatoxin occurs due to the colonization and contamination by the fungus. This can occur in crop plants in the field, at harvest, during post-harvest activities or in storage. The fungus *Aspergillus flavus* is green in color, but aflatoxin contamination is not always visible. Aflatoxin contamination can be determined through laboratory tests. The degree of aflatoxin contamination depends on temperature, humidity, and storage conditions. The most effective way to control aflatoxin contamination in susceptible crops is controlling the growth of the causative fungi. Traditionally, this can be achieved by adopting GAPs, and good harvesting, drying and storage practices. Pest management is also important since insects and diseases expose susceptible plant tissues to colonization of the fungi.

Farmers and processors selling aflatoxin contaminated products are generally penalized with a much lower price than those selling uncontaminated goods. In developed countries where phyto-sanitary standards are strictly implemented, consignments with harmful levels are rejected and at times the suppliers are blacklisted or fined. Different countries have established limits for the aflatoxin contamination on the products which they import. For example, the European Union allows no more than 10 parts per billion (ppb) of all aflatoxins, except B1 which has a maximum limit of 5 ppb. The US has a maximum allowable limit of 20 ppb of all aflatoxins, combined.

Most Common Pests in Sri Lanka

Capsicum crops in Sri Lanka are affected by various pests that can significantly reduce yield and quality. Here are some of the most common pests:

Pest	Description	Symptoms	Management
Aphids (Aphis gossypii and Myzus persicae)	Small, soft-bodied insects that feed on plant sap.	Curling leaves, stunted growth, and the potential transmission of viruses.	Use of insecticidal soaps, neem oil, and encouraging natural predators like ladybugs.
Thrips (Frankliniella spp.)	Tiny, slender insects that can cause	Silvering of leaves, distorted growth, and scarring on fruits.	Regular monitoring, use of yellow sticky traps, and applying

Pest	Description	Symptoms	Management
	damage by feeding on flowers and leaves.		insecticides when populations are high.
Whiteflies (Bemisia tabaci)	Small, white, flying insects that suck sap from leaves.	Yellowing of leaves, stunted growth, and sooty mold from honeydew excretion.	Use of yellow sticky traps, insecticidal soaps, and introducing natural predators like Encarsia formosa.
Spider Mites (Tetranychus spp.)	Microscopic pests that thrive in hot, dry conditions.	Fine webbing on leaves, stippling, and yellowing foliage.	Regularly spraying with water to reduce populations, using miticides, and promoting beneficial insects.
Fruit Borer (Helicoverpa armigera)	A caterpillar that bores into fruits and flowers.	Holes in fruits, rotting at the entry points, and reduced marketability.	Use of pheromone traps, timely application of insecticides, and handpicking larvae.
Cutworms (Agrotis spp.) :	Larvae that feed on young plants at the soil level.	Severed stems and missing seedlings.	Use of barriers, such as collars around seedlings, and applying insecticides as needed.
Leaf Miners (Liriomyza spp.)	Larvae that create tunnels within the leaves.	Distorted leaves and reduced photosynthesis.	Removal of infested leaves and applying appropriate insecticides.

Figure 14: White Fly

Figure 15: Thrips Damage

Figure 16: Aphids on Leaf

Figure 17: Mites Damage

Integrated pest management strategies, including cultural practices, biological controls, and targeted chemical applications, are essential for effectively managing these pests in Capsicum cultivation in Sri Lanka. Regular monitoring or vigilance and timely interventions by the farmers can help minimize pest damage and improve crop health.

When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Most Common Diseases in Sri Lanka

In Sri Lanka, Capsicum is susceptible to several common diseases, which can significantly impact yield and quality. Here are some of the most prevalent diseases:

Disease	Description	Symptoms	Management
Damping off	Primarily caused by fungi such as Pythium, Rhizoctonia, and Fusarium, damping off affects seedlings, leading to poor germination and growth.	Seed rot, wilting, and collapse of seedlings.	Improve drainage, avoid overcrowding, use sterile media, and apply fungicides as needed.
Bacterial Leaf Spot	Caused by *Xanthomonas campestris*, this disease affects foliage and fruits.	Small, water-soaked spots on	Use resistant varieties; practice crop rotation;

Disease	Description	Symptoms	Management
		leaves; yellowing and wilting.	apply copper-based bactericides.
Powdery Mildew	A fungal disease caused by *Leveillula taurica*, thrives in dry, warm conditions.	White, powdery patches on leaves and stems.	Improve air circulation; apply fungicides; remove infected plant debris.
Botrytis Gray Mold	Caused by *Botrytis cinerea*, especially problematic in high humidity.	Gray, fuzzy mold on fruits and leaves; soft rot.	Ensure proper spacing; avoid overhead watering; apply fungicides as needed.
Phytophthora Blight	Caused by *Phytophthora capsici*, leading to root and fruit rot.	Wilting plants; black lesions on stems; fruit rot.	Use resistant varieties; improve drainage; apply fungicides; manage irrigation carefully.
Virus Diseases	Includes Tobacco Mosaic Virus (TMV) and others, often transmitted by aphids.	Mottled leaves; stunted growth; poor fruit development.	Use virus-free seeds; control aphid populations; remove infected plants.
Fusarium Wilt	Caused by *Fusarium oxysporum*, it affects the vascular system of the plant.	Yellowing leaves; wilting; plants may collapse.	Use resistant varieties; practice crop rotation; improve soil health.
Anthracnose	Caused by *Colletotrichum spp.*, affects fruits and leaves, particularly in wet conditions.	Dark, sunken lesions on fruits; leaf spots.	Apply fungicides; improve air circulation; avoid overhead irrigation.

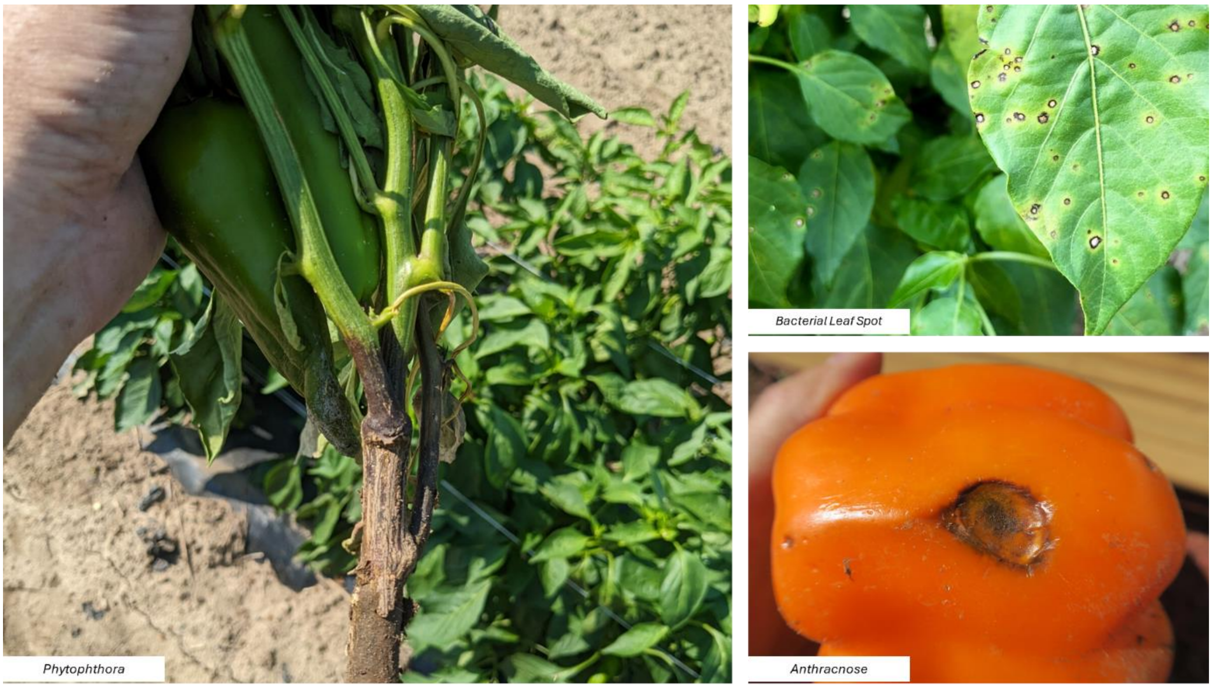


Figure 18: More Diseases of Capsicum

Figure 19: Damping Off

Figure 20: Fusarium Wilt

Effective management practices involve a combination of cultural practices, resistant varieties, and chemical controls tailored to specific diseases and local conditions. Regular monitoring or vigilance and timely intervention by the farmers are crucial to minimizing disease impact on Capsicum crops in Sri Lanka.

When chemical control is practiced, only pesticides that are registered in Sri Lanka should be used at DOA recommended amounts.

Chemical Control of Pests and Diseases

Chemical Control of Pests

Pest	Insecticide	Dosage	Management
Aphids	Imidacloprid	0.1-0.2 L/ha	Monitor populations regularly; treat when thresholds are reached. Rotate with other classes to prevent resistance.
Thrips	Acetamiprid	0.15-0.3 L/ha	Apply at the first sign of infestation; repeat applications as needed. Use in conjunction with IPM practices.
Leaf Miners	Spinosad	0.1-0.2 L/ha	Monitor for early signs; apply preventively if populations increase. Rotate with different insecticides.
Whiteflies	Pyriproxyfen	0.3-0.5 L/ha	Apply when populations are detected; consider using yellow sticky traps for monitoring.
Fruit Flies	Malathion	1.0-1.5 L/ha	Monitor traps regularly; apply treatments during fruiting periods to prevent infestations.
Cutworms	Chlorpyrifos	1.0-2.0 L/ha	Apply at planting or when larvae are first detected; monitor for re-infestation.
Spider Mites	Abamectin	0.2-0.4 L/ha	Apply during early infestation stages; rotate with miticides to avoid resistance.
Corn Borer	Lambda-cyhalothrin	0.2-0.5 L/ha	Apply at first signs of damage; monitor for subsequent generations and reapply as needed.
Scale Insects	Oil-based Insecticides	2.0-3.0 L/ha	Apply as a foliar spray; ensure thorough coverage and treat during dormancy if possible.
Mealybugs	Horticultural Oil	2.5-5.0 L/ha	Apply during the growing season; monitor and treat as needed, ensuring good coverage of the plant.

Chemical Control of Diseases

Disease	Chemical	Dosage	Management
Powdery Mildew	Sulfur	2.5-3.0 kg/ha	Apply at the first sign of infection; repeat every 7-14 days as needed. Ensure good air circulation in the canopy.
Bacterial Spot	Copper Hydroxide	2.0-3.0 kg/ha	Apply preventively during wet conditions; ensure thorough coverage

Disease	Chemical	Dosage	Management
			on foliage. Rotate with non-copper options to avoid resistance.
Phytophthora Blight	Metalaxyl	1.0-1.5 L/ha	Apply as a soil drench or foliar spray; monitor for wet conditions and apply preventively.
Fusarium Wilt	Carbendazim	0.5-1.0 L/ha	Use as a seed treatment; practice crop rotation with non-host crops to reduce pathogen levels.
Anthracnose	Chlorothalonil	1.0-2.0 L/ha	Apply at first signs of disease; repeat applications every 10-14 days during wet weather.
Downy Mildew	Dimethomorph	0.5-1.0 L/ha	Apply preventively before symptoms appear; monitor humidity levels to determine timing.
Sclerotinia Rot	Boscalid + Pyraclostrobin	1.0-1.5 L/ha	Apply during flowering; use in conjunction with good cultural practices to minimize risk.
Root Rot	Trichoderma spp.	1-2 kg/ha	Apply as a soil amendment or drench; enhances beneficial microbial activity to suppress pathogens.
Alternaria Leaf Spot	Azoxystrobin	0.5-1.0 L/ha	Apply at the first sign of symptoms; repeat every 14 days as necessary, especially in humid conditions.
Viral Diseases	Insecticides (e.g., Imidacloprid)	0.1-0.2 L/ha	Control insect vectors to prevent spread; apply as needed based on pest monitoring.

Guidelines for the Safe Use of Pesticides and Other Agro-Chemicals

1. Personal Protective Equipment (PPE)
    - Wear gloves, masks, goggles, and long-sleeved clothing to minimize chemical exposure.
2. Proper Training
    - Ensure all personnel are trained in safe handling and application techniques, with regular refresher courses.
3. Correct Dosage and Application
    - Follow manufacturer’s instructions to avoid overuse and environmental harm.
4. Timing of Application
    - Apply pesticides early morning or late afternoon to reduce evaporation and protect beneficial insects. Avoid pre-rain application.
5. Buffer Zones

- Maintain buffer zones around water bodies to prevent contamination.

6. Mixing and Loading
    - Mix pesticides in designated areas away from water sources and use proper containment.
7. Safe Storage
    - Store pesticides in a cool, dry place, out of reach of children and elder people and animals, with proper labeling.
8. Disposal of Containers
    - Dispose of containers according to local regulations and do not reuse them.
9. Monitoring and Record Keeping
    - Keep records of pesticide applications and monitor pest populations regularly.
10. Integrated Pest Management (IPM)
    - Combine chemical controls with other practices to reduce pesticide reliance.
11. Emergency Procedures
    - Have emergency procedures for accidental exposure or spills, including first-aid kits and contact numbers.
12. Environmental Impact Assessments
    - Conduct assessments to understand the impact on ecosystems and human health.

HARVESTING

Harvesting capsicum at the right time is vital for maximizing flavor, texture, and nutritional value. By observing the signs of maturity, such as color development, size, texture, and physiological indicators, growers can determine the optimal time for harvest. Employing proper harvesting techniques further ensures that the fruits retain their quality until they reach the consumer. With careful attention to these factors, growers can enjoy a successful capsicum harvest.

Signs of Proper Maturity

Color Development

One of the most visible indicators of capsicum maturity is its color. Capsicum fruits change color as they ripen, typically transitioning from green to yellow, orange, or red, depending on the variety. A fully mature Pepper will exhibit a vibrant and uniform color. For instance:

- Green Capsicum: While some varieties can be harvested when green, they may not have developed their full flavor profile.
- Red, Yellow, or Orange Capsicum: These colors indicate full ripeness and peak sweetness, as the fruit accumulates sugars during the ripening process.

Size

Another critical factor is the size of the capsicum. Mature capsicum fruits reach a certain size that is characteristic of their variety. Growers should refer to seed packets or local horticultural guidelines to determine the expected size for harvesting. An adequately sized fruit is generally firmer and heavier, indicating that it has reached its full potential.

Texture and Firmness

Mature capsicum should feel firm to the touch. As they ripen, the skin becomes taut, and the fruit should exhibit a slight sheen. If the fruit feels soft or has blemishes, it may be overripe or starting to decay. A firm texture is indicative of freshness and optimal quality for consumption.

Physiological Signs

The stem attached to the capsicum can also provide clues about maturity. A ripe capsicum will have a stem that is firm and green, indicating that the fruit is still connected to the plant's nutrient supply. If the stem begins to dry out or turn brown, it may signal that the fruit is overripe or past its prime.

Harvesting Techniques

When harvesting capsicum, it is essential to use proper techniques to avoid damaging the fruit or the plant. The following steps should be followed:

1. Use Sharp Tools: Utilize sharp scissors or pruning shears to cut the fruit from the plant, ensuring a clean cut that minimizes damage.
2. Leave a Stalk: It is advisable to leave a small section of the stem attached to the fruit to prolong shelf life and reduce the risk of rot.
3. Handle with Care: Capsicum fruits are delicate, so handle them gently to avoid bruising.

Additional Harvesting Considerations

Peppers are harvested when they are immature and green (fruit is firm, well coloured and of good size), but when they have reached full size and maximum wall thickness. Each field is harvested multiple times by hand. Some are picked after they have ripened to red or other colours. Peppers destined for wholesale shipment are usually washed, sorted and graded on a packing line.

Table 4: Harvesting Tips for Farmers

Harvesting Tips for Farmers
• Use appropriate harvesting containers • Thoroughly clean containers with chlorinated water before harvesting • Harvest when quality is at a maximum level, especially size, color and shape

Maturity is determined when the fruit is smooth and firm to the touch (it is a function of wall thickness), the colour is deep green, and the size is what the market wants. Peppers for the fresh market must be 8 cm in diameter and not less than 9 cm long. They can also be harvested red, which are considerably sweeter and more flavourful. Mature yellow, orange and purple Peppers, together with red Peppers, represent a generally higher-value product in fresh market channels.

Peppers are generally broken off from the plants with the stems left attached to the fruit. For sweet peppers strong cloth picking bags, which are suspended from the shoulders of the pickers, are preferable to baskets or boxes. This frees both hands for rapid and careful removal of the fruit from the plants. Hard picking containers may become rough and sandy, and as a result cause damage to the peppers. Pepper fruit is later carried to a central point where it is graded and packed into standard baskets or put into containers for delivery to the market or process ing plant. The red-ripe peppers are sometimes sun dried and stored in bags.

Care should be taken when breaking the peppers from the plants, as the branches are often brittle. Hand clippers or pruners can be used to cut peppers from the plant to avoid excessive stem breakage. The number of peppers per plant varies with the variety. Pepper plants may produce six to eight or more fruit per plant.

For the fresh market, or when the fruit is to be stored, peppers should be cut cleanly from the plant, using a hand clipper or sharp knife, leaving about a 2 cm section of the pedicel (stem) attached to the fruit. A clean cut is important as such cut surfaces heal more quickly. This reduces incidence of decay in storage and during transport to the market. Care should also be exercised to ensure that the stems do not cause puncture wounds in harvested fruit.

POST-HARVEST HANDLING

Green Peppers are hand harvested for the fresh market when they are at the mature green stage. Coloured or specialty Peppers are allowed to ripen fully on the plant. Coloured peppers generally weigh more than green fruit.

The fruit must be handled carefully to prevent skin breakage and puncturing that could lead to decay. Cooling peppers, as soon as possible, after harvest, will extend their shelf life. Once the fruit is cooled, it can be stored for two to three weeks under the proper conditions. Rapid precooling of harvested sweet peppers is essential in reducing marketing losses

The fruit is then graded by size and condition and packed according to the preference of the market/buyer.

Table 5: Post-Harvest Tips for Farmers

Post-Harvest Handling Tips for Farmers

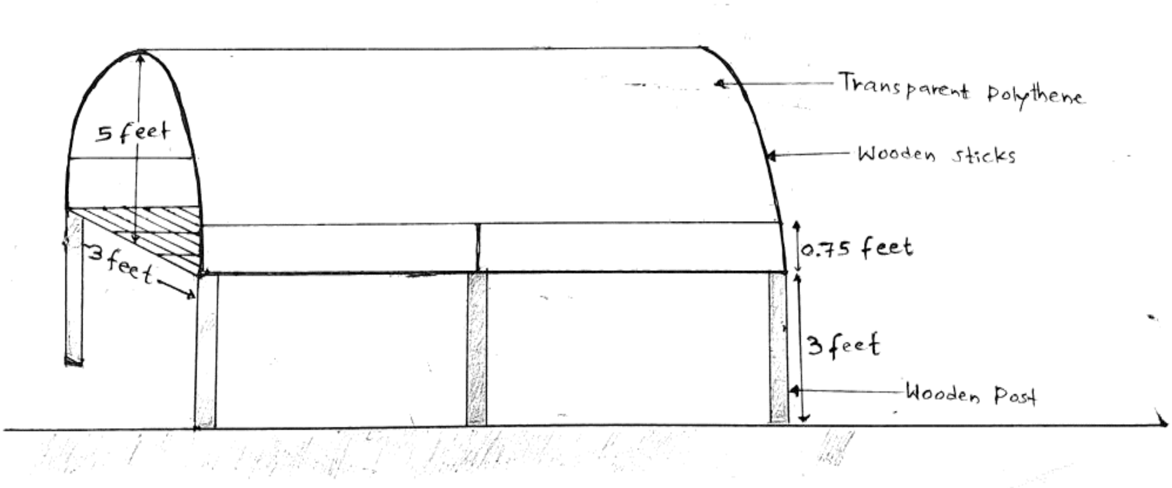
- **Place harvested crop under shade as soon as possible after harvest**
- **Avoid direct contact of the harvested crop with the ground**
- **Do not store in hot and unventilated spaces**
- **Prepare produce for market making sure they are not bruised or scared**
- **Place produce in proper containers as required by the market**
- **Bring product to market as soon as possible after harvest**
- **Workers handling product must be healthy and must wear protective gear to avoid contamination**

Key cold chain management parameters include temperature control, as capsicum should be stored at 7-10°C to slow down respiration and delay spoilage. They are subject to cold damage at temperatures below 7 °C, and temperatures above 12 °C encourage ripening and spread of bacterial soft rot. Humidity levels should be maintained between 90-95% to prevent dehydration, while careful handling is essential to avoid bruising, which can lead to decay. Additionally, it is important to monitor ethylene exposure, as capsicum is sensitive to this gas, which can accelerate ripening and deterioration. Regular inspection for signs of pests or diseases and proper ventilation during storage can also help preserve the quality of capsicum postharvest.

It is a commercial practice to wax fresh-market peppers. Only a thin coating should be applied. Waxing provides some surface lubrication, which not only reduces abrasions in transit but also reduces shrinkage; the result is longer storage and shelf life.

Senescence of sweet peppers is hastened by ethylene. Therefore, it is not a good practice to store peppers with apples, pears, tomatoes, or other ethylene-producing fruit types in the same room.

__ANNEX 1: LOW-COST ELEVATED NURSERIES__



- **Height - 2.5 - 3 feet**
- **Length - 15 feet**
- **Width - 3 feet**
- **15 Nursery trays**
- **810 Seedlings with 54-hole trays**
- **1,500 Seedlings with 100-hole trays**
- **Polythene bags - 650 bags (4 by 5 inches)**

ANNEX 2: SOIL TEST RESULTS AND FERTILIZER RECOMMENDATIONS

Badulla Vegetables Soil Test Results

Sample Code	Lab No.	pH	OM	EC	Ca	Mg	K	NH_4-N	P	S	Cu	Fe	Mn	Zn	CEC	Ca/Mg	Mg/K	Ca/K	Ca+Mg/K	Ca sat
		1:2.5, H_2O	%	µS/cm	Exchangeable (meq/100g)					Available (ppm)					cmol/kg					
Erabadda – 1	R9 483	6.21	2.15	95.70	1.70	0.92	1.05	263.60	53.00	261.00	4.20	48.80	6.90	3.00	3.70	1.85	0.88	1.62	2.50	46.32
Erabadda – 2	R10 483	6.35	2.29	102.70	1.85	0.69	0.3	346.40	208.00	95.00	9.10	366.00	82.00	4.00	2.80	2.68	2.30	6.17	8.47	65.14
Puranwela	W1 483	6.25	2.02	108.30	2.78	1.83	0.61	247.90	240.00	20.00	6.70	416.00	15.20	4.40	5.20	1.52	3.00	4.56	7.56	53.26
Diwurumwela	W2 483	5.95	2.96	93.40	3.25	1.55	1.02	323.40	352.00	29.00	8.90	920.00	26.40	5.70	5.80	2.10	1.52	3.19	4.71	55.84
Alawathugoda – 1	W3 483	6.63	3.09	85.10	4.43	1.96	1.88	224.80	233.00	301.00	7.30	146.20	30.00	6.10	8.30	2.26	1.04	2.36	3.40	53.57
Alawathugoda – 2	W4 483	6.44	3.77	89.80	3.46	1.25	1.42	215.70	225.00	36.00	7.80	328.00	29.20	6.70	6.10	2.77	0.88	2.44	3.32	56.44
Gawarammana	W5 483	6.51	2.02	99.80	3.41	1.89	1.17	217.00	307.00	31.00	7.10	830.00	13.00	5.00	6.50	1.80	1.62	2.91	4.53	52.70

Interpretation:

- Low Potassium in two samples
- Low Sulphur in 3 samples
- Sulphur very high in two samples. Could be error from the Lab
- Copper and Zinc deficient
- Mn deficient except in one sample
- CEC low
- Cation ratios are narrow
- Calcium saturation is low except in one sample

Fertilizers:

- Nitrogen as required as Urea
- MOP for only two sites
- MgSO4
- CaCO3 at land preparation
- Foliar Micronutrients T-Flush

Plot/Application	Unit	Initial	Development	Production
Urea	Kg	5.10	5.10	14.03
MOP	Kg	4.12	4.12	11.34
MgSO4	Kg	3.60	3.60	9.90
Applications per Week		2		
Phosphoric Acid (ml)	ml	307.2	307.2	307.2
Application every two weeks				

Apply Calcium in the form of CaCO3 at a rate of 200 Kg/Half Acre during land preparation
Foliar Applications of Micro Nutrients (T-Flush 100 ml/16 L) Are also Recommended weekly. Very important

ANNEX 3: 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 4: SAFE USE OF PESTICIDES BY FARMERS

The ASMP does not recommend the use of pesticides except on an emergency basis when the survival of the crop is in eminent danger. When pesticides are required, the road map to assure their safe use is as follows:

- Use only recommended and approved agrochemicals that have not expired
- Store chemicals in well-ventilated storage boxes, rooms or warehouses that are kept locked and that are built for this purpose
- Use only clean and calibrated sprayers dedicated to the chemicals being sprayed only i.e. weed killer containers should not be used to spray fungicides
- Use measuring devices to accurately measure recommended dosages or amounts of the chemicals
- Mix spray solutions or suspensions thoroughly with clean water and away from the field to be sprayed avoiding spillages
- Pour leftover mixes together with new mixes of the same product instead of discarding them in the soil or in streams
- Spray only in the early morning or late afternoon to minimize the effect of temperature and wind on the spray operation
- Spray equipment operators must wear protective clothing and equipment in accordance with the toxicity of the chemical being sprayed
- Dispose of chemical containers properly either by handing them to the proper authorities (Ministry of the Environment) or by storing them in the proper location after they have been punctured to avoid stagnant water. Burning of hazardous chemicals is to be avoided
- Keep sprayers and other spray equipment in good working condition