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Agriculture Sector Modernization Project

OPERATIONAL MANUAL

CHILI

AGRICULTURE SECTOR MODERNIZATION PROJECT

A PARK
AGRICULTURE TECHNOLOGY DEMONSTRATION PARK

Prepared by -
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PROJECT DIRECTOR'S MESSAGE

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Dr. Rohan Wijekoon
Project Director
Agriculture Sector Modernization Project

Contents

1. INTRODUCTION

Chili peppers, also spelled Chile or Chilli, are varieties of the berry-fruit of plants from the genus *Capsicum*, which are flowering plants members of the nightshade family Solanaceae, native to the Americas, cultivated worldwide.

Capsicum plants originated in modern-day Bolivia and have been a part of human diets since about 7,500 BC. They are one of the oldest cultivated crops in the Americas. Origins of cultivating chili peppers have been traced to east-central Mexico some 6,000 years ago, although, according to research by the New York Botanical Garden press in 2014, chili plants were first cultivated independently across different locations in the Americas including highland Bolivia, central Mexico, and the Amazon. They were one of the first self-pollinating crops cultivated in Mexico, Central America, and parts of South America.

Peru has the highest variety of cultivated *Capsicum* diversity because it is a centre of diversification where varieties of all five domesticates were introduced, grown, and consumed in pre-Columbian times. The largest diversity of wild *Capsicum* peppers is consumed in Bolivia.

1.1 Optimal Ecological Requirements

Chilies can be grown under tropical and sub-tropical climates. It can be cultivated upto an altitude of 2000m. However, pungent varieties or varieties suited for spices cannot be grown at higher altitudes.

A warm humid climate favours growth while warm and dry weather enhances fruit maturity. It can be grown successfully as a rain-fed crop in areas receiving an annual rainfall of 850-1200 mm. Heavy rainfall leads to poor fruit set and in association with high humidity leads to rotting of fruits.

A soil temperature of 10°C retards plant development, whereas 17°C causes normal development. A temperature ranging from 20-25°C is ideal for chilies.

The tops of plants will continue to develop at higher temperatures, but root development is retarded at soil temperatures of 30°C and above. In chilies, fruit development was found to be adversely affected at temperatures of 37°C or more.

High temperature associated with low relative humidity at flowering increases the transpiration resulting in abscission of buds, flowers, and small fruits. Average high night temperatures were found to be responsible for the high capsaicin content.

A day length of 9-10 hours light stimulates plant growth and increases the productivity by 21 - 24% besides improving the quality of capsicum.

Soils

Chilies are grown in a variety of soils provided they are well drained, well aerated, and rich in organic matter. The drained conditions cause shedding of leaves, sickly appearance, and fruit drops. It can be grown successfully in light textured soils by providing adequate irrigation and manuring. Heavy textured soils are also suitable for rainfed crops. An ideal soil for chili is light loamy or sandy loam rich in lime and organic matter. Strongly acid and alkaline soils are not suitable for chili growing. Chili can be successfully grown in soils with soil pH of 6-7. In acid soils, liming is beneficial, however, high salinity reduces germination and vigour of plants.

2. LAND PREPARATION

2.1 Primary Land Preparation

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

2.2 Secondary Land Preparation

1. Heavy Soil Textures
    a. Disk harrow using a disk harrow implement with disks having a diameter of 40 cm.
    b. Two passes perpendicular to each other are required.
2. Light Soil Textures
    a. Cultivate using a tine tiller implement.
    b. Two passes may be required in sandy clay loam soils.

2.3 Tractor

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

2.4 Drainage

Drainage is of particular importance for the Chili 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 Fusarium Wilt, Phytophthora root rot and other soil borne diseases affecting Chili.

1. Light Texture Soils
    a. Light textured soils are preferred for the cultivation of the Chili.
    b. Sloping handmade ditches to evacuate water from rainfall quickly 30 cm wide x 15 cm deep.
    c. 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.
    d. 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.
    e. 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
    a. Heavy texture soils such as clays are not very suitable for the Chili cultivation.
    b. Sloping drainage secondary canals 45 cm wide x 30 cm deep at 20 m intervals
    c. 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
    a. This type of soils much be avoided for Chili cultivation.
    b. Drainage lines 45 cm wide and 45 cm to 60 cm deep at 5 m to 10 m intervals
    c. 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
    a. Backhoe Excavator or similar with 30cm or 45cm wide bucket

3. VARIETIES

The MICHHY 1 hybrid is the first local Chili hybrid developed by the DOA. The seed is being produced by the ASMP for Chili farmers around the Country. It is now the preferred seed for Chili cultivation. This hybrid has shown that it adapts very well to high density planting and to all the major Chili growing areas in Sri Lanka in Maha and Yala seasons.

Following are some basic facts about the hybrid[1]:

1. Pedigree: Galkiriyagama inbred line x MI Waraniya 1 inbred line
2. Origin: FCRDI/Mahailuppallama
3. Year of release: 2015
4. Longer crop cycle (more than 180 days) compared to other open pollinated chili varieties released by the DOA.
5. The MICH HY 1 plant is a highly branched and tall plant (75 cm)
6. The pods are highly pungent and long (14cm) with light green color.

The hybrid is Moderate Resistant to the Chili Leaf Curl Complex, the major pathological problem for Chili production in the country.

4. PLANTING MATERIAL

Chili 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).

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 1: Cocopel Disks Specifications

Cocopel, 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 Chili 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.

[1] https://www.plantsandseeds.biz/ad/3713/chilli-seeds-mich-hy1-miris-hybrid-10g

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.

Figure 2: Cocopel Germination and Growth Disks

5. HIGH DENSITY PLANTING

5.1 Procedure

The Chili 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 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.

POPULATION DENSITY

74,667/Ha
29,915/Acre
14,957/Half Acre

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 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.

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 30 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.

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.

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.

5.2 Plant Spacings Within the Crop Rows

Chili	0.30 m

5.3 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

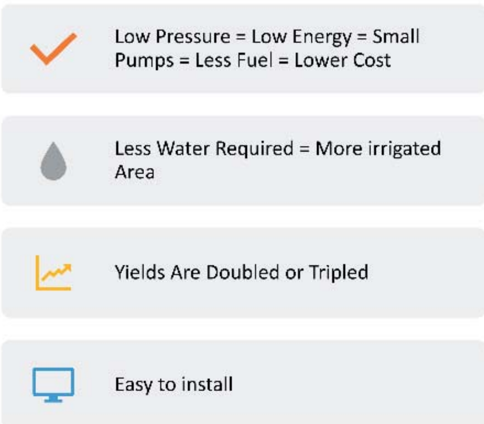
6. IRRIGATION AND FERTIGATION

6.1 Irrigation

Chili 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 3: Micro-Sprinkler System

Figure 5: 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)

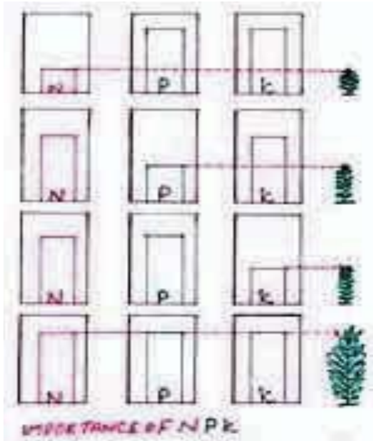
6.3 Water Application

The Chili 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 Chili in Polonnaruwa using the drip tape irrigation system with one drip tape line in the middle of the planting bed.

Table 1: Irrigation Schedule

Irrigation Schedule	Year 1		Year 2		Year 3	
Irrigation Time (Hours/ Minutes)	0	26	1	30	1	15

6.4 Fertigation



Chili is a relatively heavy user of nitrogen (N), phosphorus (P) and potassium (K). Hence, application of fertilizers is essential to boost the yield and get higher returns. The deficiency of micronutrients in some soils may also limit the production.

Below, in graphical form, is the relative nutrition (N, P, K) required according to the stage of development of the chili crop:

The fertilizer application is based on soil test results. The results for the Polonnaruwa Chili Cluster area soil tests indicated the following:

Organic matter very low
Magnesium (Mg) and Potassium (K) levels low as well
Phosphorus very deficient
Sulphur, Copper, and Zinc also deficient
Cation Ratios very narrow, especially Mg/K call for soil amendments with Mg to increase the Mg/K ratio

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

Nitrogen (N) required regardless of levels of Organic Matter and soluble N in the soil
Phosphoric Acid will add Phosphorous (P) to the soil and will prevent irrigation system from clogging
TSP will supply the Potassium (K) required in most locations
Magnesium Sulphate ($MgSO_4$) will increase Mg/K and will provide required Sulphur (S)
Foliar fertilization with Ino-K Foliar Micronutrients or similar

Based on the above considerations and a review of literature for chili fertilization, the nutrients, and the amounts to be applied are shown below in elemental and oxide form:

Recommendation	N	P	K	Mg
Kg/ Ha	150.0	75.0	150.0	50.0
Lb/ acre	150.0	75.0	150.0	50.0
Kg/ acre	68.2	34.1	68.2	22.7

Table 2: Nutrition Quantities

Recommendation	Urea	P_2O_5	K_2O	MgO
Kg/ Ha	326.1	171.8	180.8	82.9
Lb/ acre	326.1	171.8	180.8	82.9
Kg/ acre	148.2	78.1	82.2	37.7

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

Kg/ Acre	Urea	P Acid	TSP	MOP	$MgSO_4$
Fertilizer per year (Season)	148	13	153	103	227

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

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

Ratio Based on Tree Age	Initial	Mid	Late	Total
Urea	9	99	41	148.3
P Acid	4.3	4.4	4.3	13.0
TSP	50.4	52.0	50.4	152.8
MOP	34.1	35.1	34.1	103.3
$MgSO_4$	75.0	77.3	75.0	227.3

Table 4: Quantities of fertilizer as per stage of development

Considering a Chili crop cycle in Sri Lanka of 17 weeks, the potential number of fertigation weeks is also 17 weeks. Thus, the fertilizer quantities per Acre per week are as follows:

Kg/Acre	Initial	Mid	Late
Urea	1.75	14.08	8.20
P Acid	0.86	0.63	0.86
TSP	10.09	7.42	10.09
MOP	6.82	5.02	6.82
$MgSO_4$	15.00	10.71	15.00

Table 5: Week-wise, fertilizer quantities

These amounts are to be applied in 3 cycles per week. On a per application basis (irrigation cycle), the amounts of fertilizer materials required are:

Kg/Acre/Week	Initial	Mid	Late
Urea	0.583	4.694	2.732
P Acid	0.286	0.211	.286
TSP	3.362	2.474	3.362
MOP	2.273	1.673	2.273
$MgSO_4$	5.000	3.571	5.000

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

These amounts are further reduced based on the net area cultivated in Chilis. For a production plot with size of half an Acre, the net area to be fertigated is only 0.19 Acres. Following are the fertigation recommendations for this net area for the Polonnaruwa Chili Cluster:

Kg/Acre/Application	Year 1	Year 2	Year 3+
Urea	0.11	0.89	0.52
TSP	0.64	0.47	0.64
MOP	0.43	0.32	0.43
$MgSO_4$	0.95	0.68	0.95
Applications per week	3		
P Acid Application every two weeks (ml)	32.3	23.8	32.3
In addition, foliar applications of micronutrients are required on a weekly basis, especially Copper (Cu) and Zinc (Zn).			

Table 7: Fertigation Recommendations per Application per Half Acre Plot

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 chili 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

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 chili 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):

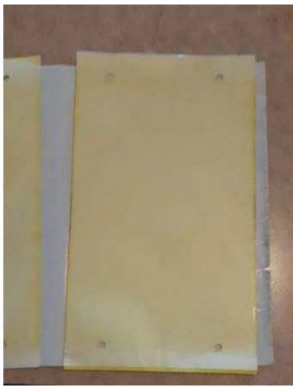
1. Support Structure:	• Wooden or metal poles: 80 poles (assuming poles are placed every 15 feet). • Galvanized wire or strong twine: Approximately 3,000 feet.
2. Netting:	• High-quality, fine (40 mesh to 60 mesh) mesh netting: Approximately 2 acres of netting to allow for overlap and secure attachment.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

8.2 Yellow Sticky Traps



Sticky yellow 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.

For Chili, 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".

Most Common Pests and Diseases in Chili in Sri Lanka

The most common Chili pests and diseases found in Sri Lanka during the ASMP are discussed below:

8.3 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 chili 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.

8.4 Whitefly

Whiteflies (both immature and adult stages) are white or yellow in color, with a dusty appearance, and very small in size (2-3 mm). They are most often found under the leaves at the top of the plant. They are very active and fly if disturbed. In heavy infestations, disturbing the plant will result in a small white cloud of whitefly adults taking flight. They damage the plant through sucking the sap from the leaves. Heavily infected plants will be easily visible due to leaves wilting. Significant yield losses can occur.

Control Alternatives

Cultural:

Whiteflies prefer cotton, melons and cole crops. Plant peppers away from these crops Maintain good sanitation in areas of winter and spring host crops and weeds by destroying and removing all crop residues as soon as possible. Control weeds in non-crop areas including head rows and fallow fields.

Biological:

Some beneficial insects such as big-eyed bugs, lacewing (Chrysoperla) larvae and lady bird beetles' prey on whiteflies, but they seldom offer acceptable control, and are almost always killed with the first insecticide application.

Mechanical:

Yellow sticky traps

Chemical:

There are several insecticides that offer partial control. However, whiteflies are very difficult to control because they can develop resistance to insecticides quickly, particularly if those insecticides are overused. Always consider resistance management.

The reported Economic Threshold for whiteflies on chili, in India, is 2 whiteflies per leaf.

8.5 Thrips

Chili thrips feed on young leaves, stem terminals and developing flower buds with a sucking mouthpart. This causes leaves to become curled, bronzed, and distorted. Severe infestation reduces plant growth and crop yield. Detecting chili thrips is difficult because they are very small in size (< 2 mm in length). The best method for scouting for thrips is to lay a sheet of light-colored cloth or paper on the ground next to chili plants and gently shake the plant over the paper. The chili thrips will fall onto the paper and be visible. A hand lens will be helpful due to their small size.

Control Alternatives

Cultural:

Because thrips can survive as adults in leaf litter or weeds, cleaning up debris from infested plants and removing weeds are important activities to reduce the population. This is especially critical for nurseries that have had chili thrips infestations in the past.

Sticky traps can be helpful in monitoring for thrips infestation but do not provide acceptable control in a field situation. Detergent spray mixtures can also provide suppression, or even control in low populations.

Biological:

Big-eyed bugs have been reported to provide acceptable control of chili thrips in fields and nurseries When used alone, the fungal pathogen Beauveria bassiana is not effective in controlling chili thrips adults or larvae but produced better result when used in combination with an experimental product consisting of borax, orange oil and biodegradable surfactants https://entnemdept.ufl.edu/creatures/orn/thrips/chili_thrips.htm).

Research is underway to identify control with Chrysoperla (lacewing) and other beneficial insects, and some predatory mites.

Mechanical:

Sticky traps are helpful in monitoring and trapping thrips. Peripheral fine mesh insect nets can provide a barrier to thrips and are practical for use in small farmers chili fields.

Chemical:

There are several insecticides that offer acceptable control. Some biological, or biochemical insecticides that have shown promise include neem oil, horticultural oil, and the fungi, Beauveria bassiana. Some commercial products based on Beauveria bassiana may be available.

Always consider resistance management The reported Economic Threshold for thrips on chili, in India, is 8-10 nymphs or adults per leaf

8.6 Aphids

Aphids are very small (2-5 mm) insects which are usually found on the underside of leaves, near the top of the plants. They can appear as various shades of green, black, or yellow. Adult aphids can be found with or without wings. They move slowly and can cause significant damage to chilis. They suck the sap from the leaf, resulting in plants in low vigor with reduced yield. They secrete a waste product from their body, known as 'honeydew,' which falls on the leaves under their feeding site. It's not uncommon to find a black-colored mold, known as 'sooty mold,' growing on the honeydew. The honeydew attracts ants as well that can protect aphids and mealy bugs.

Control Alternatives

Cultural:

- Because aphids can survive as adults in leaf litter or weeds, cleaning up debris from infested plants and removing weeds are important activities to reduce the population.
- Because many vegetables are susceptible to serious aphid damage primarily during the seedling stage, reduce losses by growing seedlings under fine mesh covers in the nursery.
- Sticky traps can be helpful in monitoring for aphid infestation but do not provide acceptable control in a field situation.
- Detergent spray mixtures can also provide suppression, or even control in low populations Biological Natural enemies can often provide acceptable control of chili aphids in fields and nurseries that haven't been treated with broad-spectrum insecticides. Chrysoperla larvae are effective predators of aphids.
- Parasitic wasps attack aphids, laying eggs into the aphids, and the developing wasp larva eats the inside of the aphid. These parasitized aphids appear golden brown and swollen, and usually don't move.
- Pirate bugs are good predators.

Mechanical:

Sticky traps are helpful in monitoring aphids and trapping them. Peripheral fine mesh insect nets can provide a barrier to aphids and would be practical for use in chili fields.

Chemical:

There are several insecticides that offer acceptable control. Some biological, or biochemical insecticides that have shown promise include neem oil, horticultural oil, and the fungi, Beauveria bassiana. Some commercial products based on Beauveria bassiana may be available locally.

Always consider resistance management The reported Economic Threshold for aphids on chili, in India, is 5 whiteflies per leaf

8.7 Bud Mite

Bud mite, or broad mite, is a very serious pest of the chili crop. It is a shiny, white, very small (0.2 mm) insect pest. It is barely visible by the naked eye but can be seen through a magnifying glass or microscope.

Bud mite damage consists of malformation and distortion of the above-ground growth of the plant. The mites show a preference for young, developing plant tissue, like the growing tips, young leaves, and flower buds. Leaf feeding is mainly concentrated on the leaf underside near the leaf stalk, which tends to cause the leaf to turn brown and curl up.

A typical indication of an attack of bud mite is the appearance of dark brown edges at the base of young leaves. Like whiteflies and aphids, the bud mite mainly attacks during warm and dry weather conditions.

Control Alternatives

Cultural:

Because this mite can survive in leaf litter or weeds, cleaning up debris from infested plants and removing weeds can reduce the population that attacks the first crops of the growing season. This is especially critical for nurseries that have had mite infestations in the past.

Detergent spray mixtures can also provide suppression, or even control in low populations.

Biological:

While several insecticides/miticides are labeled for control of this pest, insecticidal oils (lightweight horticultural oils) or soaps are usually just as effective and less toxic to the environment. Predatory mites, such as Amblyseius ovalis can be effective in both nursery and field.

Mechanical:

Sticky yellow traps and peripheral fine mesh insect nets.

Chemical:

There are several insecticides/miticides that are effective. Insecticidal oils or soaps, and neem oil are effective. Thorough coverage is necessary, requiring spraying on the underside of leaves.

Always consider resistance management.

8.8 Damping - off

Caused by *Pythium debaryanum*, seedlings affected by damping-off fail to emerge or fall over and die soon after emergence. Stems usually have a dark, shriveled portion at the soil line. Damping-off is generally limited to areas where drainage is poor or where soil is compacted, but whole fields can be affected, especially in early plantings exposed to rain.

Symptoms vary and can appear as any of the following: seedlings fail to emerge (pre-emergence damping-off), small seedlings collapse (post-emergence damping-off) or seedlings are stunted (root rot or collar rot). Poorly drained soil is often a major contributor to this condition. Affected seedlings seldom survive to become productive plants.

The disease often infects tissue damaged by extreme temperatures, wind damage, sandblasting, or rough handling. Infections are common in stressed transplants, such as those held back or stored for a period before transplanting to the field.

Fungicide-treated seed or seed treatment is a preventive measure.

8.9 Fusarium Wilt

Fusarium oxysporum f.sp. capsici

- Fusarium wilt is characterized by wilting of the plant and upward and inward rolling of the leaves. The leaves turn yellow and die.
- Generally, it appears in localized poorly drained areas of the field where a high percentage of the plants wilt and die, although scattered wilted plants may also occur.
- Disease symptoms are characterized by an initial slight yellowing of the foliage and wilting of the upper leaves that progress in a few days into a permanent wilt with the leaves still attached.
- By the time above-ground symptoms are evident, the vascular system of the plant is discolored, particularly in the lower stem and roots.

Control Alternatives

The best preventive measure against Fusarium Wilt of Chili is to maintain the soil profile in the cultivation beds internally well drained through high planting beds (0,5 m high) and an optimum micro drainage system that evacuates rainwater quickly as it falls and avoids water-logged spots.

Other preventive and control measures include,

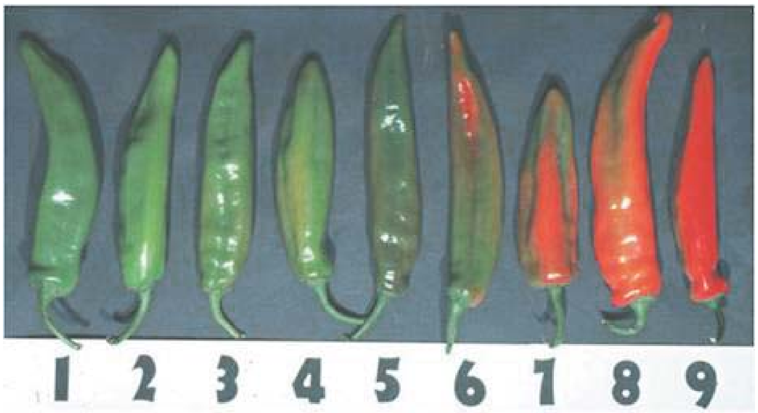
- Use of wilt resistant varieties.
- Drenching with Fytolan 0.25% may give protection.
- Seed treatment with 4g *Trichoderma viride* formulation or 2g Carbendazim per kg seed is effective.

8.10 Lodging Support

Lodging in crops is the bending over of the stems near ground level, which makes them very difficult to harvest and can dramatically reduce yield. Lodging is often a result of the combined effects of inadequate standing power of the crop, and conditions such as rain, wind, hail, topography, soil, previous crop, and others. Dwarf varieties, which are shorter, are one way of reducing lodging. The timing of lodging can control its effect on yield, disease, grain moisture, quality, and evenness of ripening.

High density chili crops that use the modern high technology introduced by the ISP-ASMP develop a vigorous and luscious biomass near the edge of the high planting beds that tends to lodge the crop. To avoid this problem, a cord or twine about 3 mm in diameter is extended along the edges of the planting beds, using wooden stakes at the beginning and the end of the bed, to support the crop at a height that reaches up to the middle of the plants to keep them from bending over.


9. HARVESTING



Chilis are usually harvested at full maturity when the fruit is completely red in color. Partially red chilis should not be picked as they contain higher moisture content and take longer to dry. The most desirable and highest value chilis are fully ripe, fresh, and free from diseases, mechanical injuries, insects, blemishes, and sunscald. These will bring the best price and sell quickly.

Harvesting of red chili is not a "one time" event. Chilis mature over an extended time so harvest also occurs over an extended period. Harvesting fruit encourages the plant to produce more fruit, so it's important that fruit does not remain on the plant any longer than necessary to reach maturity. On average, growers will harvest chilis over 6-10 separate harvests (8-10 for Dandicut varieties) which will carry the harvest over a period of 2-4 months.

It is important that farmers observe the weather forecasts and plan their activities accordingly. Picking and drying on cloudy and rainy days will lead to reduced quality.

Mature chilis will come off the plant easily, whereas immature chilis will be more difficult to remove from the plant. Chili color is a good indicator of maturity. Workers should select mature fruit for harvest and use gentle force to remove the fruit. Pulling or jerking of the fruit can damage the plant or bruise fruit.

When harvesting green Chili, the color index should be "5", which is a deep green color.

9.1 Preparing of Harvest

Harvest should take place when the field is dry. Muddy fields decrease harvest efficiency and can lead to increased contamination of the fruit. Chili plants should be free of dew each day before harvest starts. Delaying harvest until mid-morning is usually enough, but plants should be checked before starting.

Workers must be given Personal Protective Equipment to use during harvest, including gloves, surgical mask to cover mouth and nose, a reusable cloth apron and washing facilities to wash hands, face, etc. These are important in order to provide protection from capsaicin, an active component of chili peppers. Capsaicin is an irritant for mammals, including humans, and produces a sensation of burning in any tissue with which it comes into contact.

Workers must be trained to avoid touching their eyes, faces or other body parts when harvesting chilis. Chilis should be picked and immediately placed in well-ventilated plastic crates. Burlap or jute bags do not provide adequate ventilation and can lead to fungal contamination and secondary disease infection. Crates should be washed and disinfected daily to reduce disease transmission. Use a mild detergent and spray with a 10% bleach solution.

Reusable harvest containers should be cleaned and sanitized regularly. A 4-step process is recommended:

1. Pre-rinse containers with water hose to remove visible soil particles.
2. Wash with dishwashing soap applied to the surface, either in dispersion or directly, to break down contaminants and soil. A brush is used to scrub the containers while they are soapy to further remove soil and other particles from the inside and outside surfaces.
3. Containers are then rinsed with water to remove soil particles, contaminant particles and any soap residues.
4. Containers are sanitized with 10% household bleach solution. Mix 13 oz bleach in 1 gallon of water and spray the harvest containers. Let containers dry.

Immediate post-harvest When chilis are harvested, they should spend no more than 1 hour in the field. It's important to move them to a shaded area within an hour or they become overheated and start to lose quality. This shade can be under trees at the field edge, under temporary shelters built in the field or on the field edge, or shelters at the farm if located close to the field. After removing the chilis from the field, it's critical to remove field heat which helps maintain fruit quality and prevent deterioration. The best way to reduce field heat is to dip the chilis in water. Farmers can construct a small concrete, open-top tank to fill with water, or purchase a plastic tank. A shade over this tank would be.

9.2 Chili Post Harvest Profile

The postharvest profile of chili peppers, as outlined by the University of California, Davis (UC Davis), includes various factors that affect the quality and shelf life of the produce. Some of the key considerations for postharvest handling of chili peppers are:

1. **Harvest Maturity:** Chilies should be harvested at the appropriate stage of maturity. The ideal maturity stage can vary based on the specific cultivar, but generally, chilies are harvested when they reach full size and attain the desired color. For example, some varieties are harvested when they are green, while others are left to ripen to red or other colors.
2. **Handling:** Careful handling is crucial to prevent physical damage to the chilies, which can lead to increased susceptibility to decay and reduced shelf life. Chilies should be handled gently to avoid bruising, cuts, or other mechanical injuries.
3. **Temperature Management:** Chilies are sensitive to temperature and should be promptly cooled after harvest to remove field heat. The ideal storage temperature for chilies is around 45-50°F (7-10°C) with high humidity to maintain quality and minimize water loss.
4. **Packaging:** Proper packaging is essential to protect chilies from physical damage and to provide good ventilation to prevent moisture buildup, which can lead to decay. Perforated plastic bags or ventilated containers are commonly used for packaging chilies.
5. **Ethylene Sensitivity:** Chilies are sensitive to ethylene, a natural plant hormone that can accelerate the ripening and deterioration of produce. Therefore, it is important to store chilies away from ethylene-producing fruits, such as apples, bananas, and tomatoes.
6. **Quality Evaluation:** Regular quality assessments should be performed to identify any signs of deterioration, such as shriveling, softening, mold growth, or decay. Prompt removal of any damaged or deteriorating chilies can help maintain overall quality.
7. **Postharvest Treatments:** Various postharvest treatments, such as modified atmosphere packaging, controlled atmosphere storage, and application of edible coatings, may be employed to extend the shelf life of chilies and maintain their quality.

By following these postharvest guidelines, producers and distributors can help ensure that chili peppers reach consumers in optimal condition, thereby maximizing their market value and reducing food waste.

10. POST-HARVEST HANDLING

10.1 Immediate Post-Harvest

When chilis are harvested, they should spend no more than one hour in the field. It's important to move them to a shaded area within an hour or they become overheated and start to lose quality. This shade can be under trees at the field edge, under temporary shelters built in the field or on the field edge, or shelters at the farm if located close to the field.

After removing the chilis from the field, they must be transported to the drying facility as soon as possible.

10.2 Drying Processes

Once the chili arrives at the drying plant, it is critical to remove field heat which helps maintain fruit quality and prevent deterioration. The best way to reduce field heat is to dip the chilis in water in a small concrete, open-top tank or in a plastic tank. A shade over this tank would be a very good addition. The water should be mixed with two percent salt for cleaning pesticide residues. This might be enough to meet international standards for pesticide residues but would be subject to testing and approval.

Chilis should be placed into this cooling tank, loose, for 10 minutes, then removed and placed in clean ventilated plastic containers. Sorting of damaged, immature, or diseased chilis should take place at this location, before chilis are placed in the water. Sorting could also take place in the field. Once the chilis are cooled in the water bath, they should be transported to the drying area quickly. If the chilis must be transported to the drying area, the transportation method should be fast and with a smooth ride in order to reduce additional heating and bruising.

Chilis should be dried to 10% moisture. If not dried to this level, chilis can develop aflatoxin, a poisonous fungal disease that can sicken, or even kill humans and livestock. Moisture testing equipment is the best way to measure moisture precisely.

10.3 Packaging and Preparation for Storage

Once the chilis are dried to no more than 10% moisture they should go through the final sorting. Any damaged, discolored, diseased or cracked pods should be removed. The remaining chilis will be the farmer's top quality and are ready to be removed from the drying platforms, packed, and prepared for transportation to market.

Pods, even at 10% moisture, can still become infested with disease. It's important to protect chilis from disease and ventilation can be the best preventative method after harvest.

If the pods are going to the wholesale market or buyer's location, they should be placed again in clean, well-ventilated, stackable plastic baskets. These would be the same baskets used at harvest and should be cleaned and sanitized again. Do not overfill the baskets. They should be packed, stacked, and transported as quickly and smoothly as possible.

If the chilis are going into storage, they should be placed into new, or freshly washed and very clean, jute bags. Do not overfill the bags as it's important to maintain ventilation. Sew the opening of the bag closed.

Placing an identification tag onto the bag is helpful to maintain the identity of the grower. If tags are not available, other distinctive markers can be used, such as permanent markers to write the grower's name on the bag, or pieces of distinctive fabric, even with written name of farmer, can be attached to the bag.

10.4 Storage

Commercial Storage:

Most chilis go from the farm to the market and are stored by the spice company which purchases the chilis. The Commercial storage should meet minimum sanitation standards, including:

Sound structure

Floor: Brick, tile, or concrete without holes that allow rodents and insects to enter.

Roof: Rainproof and sealed against insects and rodents.

Walls: Solid construction with concrete, brick, metal. No holes open to rodents, birds, or insects.

High walls, with space between the top of wall and ceiling through which heat can escape.

Tight, fine mesh screen area between top of walls and ceiling for heat escape

Ventilation

Temperature will increase, on average, between 0.5 – 1.5 ºC for each elevated foot that heat rises. So, if a ceiling is 20 feet high, there can be a 10-20 ºC variance in temperature between the floor and ceiling. Thus, screened openings at the top of walls are of significant benefit in reducing storage temperature.

Fans that circulate air inside the warehouse help to mix the air and remove heat.

Storage bins or bags must be off the floor, either using pallets or industrial shelving.

Humidity control Dried chilis attract moisture and can become infected with disease. Ventilation in storage will help to reduce humidity. Refrigeration-based dehumidifiers are available and a viable option for large-scale storage facilities. Ground chilis will maintain color longer at lower temperatures. Pest management Exclusion is the primary method of pest management, through good construction (no gaps or openings, fine screens, etc.) and maintenance. Sanitation must be practiced. Remove all debris, dirt, dust, and trash from the storage facility before chilis are moved in Rodents should be trapped, and traps monitored daily Monitor for insects and treat premises as recommended on product labels Unless a structure is sealed and cooled with refrigeration, insect management through fumigation will have to rely on batch-fumigation instead of whole-structure fumigation. For batch-fumigation, chilis should be placed on pallets and covered with plastic sheet, fumigant product tablets are evenly distributed under the plastic and the plastic sheet is taped to the floor to prevent leaks. Follow label directions with batch-fumigation, it is very important to also spray the premises (inside and outside) with insecticide. Follow label directions.

11. COST BENEFIT ANALYSIS

Table 9: Farmer Level Cost Benefit Analysis

Item	Unit	Without project	With Project
Fresh Production /ha	mt	15	100
Production Waste	%	5%	5%
Sales Volume/ha	MT	14.25	95
Cost of Production/ ha	LKR	767,124	2,580,321
Cost/Kg	LKR	361	361
Selling Price/Kg	LKR	509	509
Gross Income/ ha	LKR	7,253,250	48,355,000
Gross Margin/ ha	LKR	6,486,126	45,774,679
Benefit/Cost Ratio		**1.4**	**2.6**

ANNEX 1: 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

Polonnaruwa Chili
Agriculture Sector Modernization Project - ASMP
Analytical Report on Soil
Description of sample(s): Moderate wet soil
Test(s) performed according to: Agro Services Internation (ASI) Methods and Walkely, and Black Method

Sample Reference: 82/CIC/0007/21-22
Sample tested on: 31/01/2022 –02/01/2022

Lab No.	pH	OM	Ec	Ca	Mg	K	N	P	S	Cu	Fe	Mn	Zn	CEC	Ca/Mg	Ca/K	Mg/K	(Ca+Mg)/K	Ca Sat.
	1:2.5, H20	%	µ5/cm	Exchangeable (meq/100g)			Total %	Available (ppm)						cmol/kg	Cation Ratios				
R8 436	7.16	0.81	51.6	3.50	0.99	0.78	43.5	33	16	8.2	215.1	86.6	1.7	5.3	3.5	4.5	1.3	5.8	66.4
R9 436	7.09	1.21	44.2	3.22	1.35	0.31	41.9	10	16	8.3	164.4	42.9	0.9	4.9	2.4	10.4	4.4	14.7	66.0
R10 436	7.15	1.21	166.9	12.47	0.64	0.07	25.3	62	19	3.9	89.0	36.6	6.5	13.2	19.5	178.1	9.1	187.3	94.6
W1 436	6.88	0.67	41.0	5.38	1.35	0.07	31.9	6	16	5.1	131.4	31.8	7.9	6.8	4.0	76.9	19.3	96.1	79.1
W2 436	6.65	1.48	61.6	6.46	1.50	0.10	27.8	7	18	4.3	146.9	38.8	18.6	8.1	4.3	64.6	15.0	79.6	80.1
W3 436	6.66	0.81	29.2	1.76	0.79	0.26	45.2	4	14	3.7	84.9	18.8	0.8	2.8	2.2	6.8	3.0	9.8	62.6
W4 436	6.53	3.22	55.3	2.64	0.99	0.69	61.9	7	17	4.2	76.2	49.3	1.1	4.3	2.7	3.8	1.4	5.3	61.1
W5 436	6.27	1.08	55.0	3.37	1.15	0.75	56.9	8	40	5.9	355.9	44.3	22.0	5.5	2.9	4.5	1.5	6.0	61.6
W7 436	7.00	0.54	79.3	1.56	0.69	0.16	99.7	8	32	3.1	98.9	21.8	1.1	2.4	2.3	9.8	4.3	14.1	64.7
W8 436	6.60	0.81	25.3	1.81	0.64	0.09	36.6	6	16	3.6	113.3	23.0	32.0	2.5	2.8	20.1	7.1	27.2	71.3
W9 436	6.56	2.02	52.4	6.04	2.17	0.48	30.9	10	36	9.2	119.9	82.8	1.1	8.7	2.8	12.6	4.5	17.1	69.5

Interpretation:
Organic matter very low
Magnesium (Mg) and Potassium (K) levels low as well
Phosphorus very deficient
Sulphur, Copper and Zinc also deficient
Cation Ratios very narrow, especially Mg/K

Recommendations:
N required regardless of levels of Organic Matter and soluble N
Phosphoric Acid will prevent irrigation system from clogging and will also add P to the soil and
TSP to add required P
MOP will add K
MgSO4 Will increase Mg/K and will provide required S
Foliar fertilization with Ino-K Foliar Micronutrients or similar

Kg/ Plot/ Application	Initial	Mid	Late
Urea	0.11	0.89	0.52
TSP	0.64	0.47	0.64
MOP	0.43	0.32	0.243
$MgSO_4$	0.95	0.68	0.95
Application per week		3	
Phosphoric Acid (ml) *Application every two week*	32.3	23.8	32.3
Foliar application of micro-nutrients weekly are required, especially Zn			

Table 8 : Fertigation Recommendations per Application per Half Acre Plot

SOIL ANALYSIS REPORT ANURADHAPURA CHILI

SAMPLE CODE	Group	LAB NO	pH	OM	EC	Ca	Mg	K	NH_4-N	P	S	Cu	Fe	Mn	Zn	CEC	Ca/Mg	Ca/K	Mg/K	Ca+Mg/K	Ca Sat.
B G Kumarasinghe	1	B10 428	6.89	2.15	328.0	6.39	2.91	1.41	78.1	126	39	11.1	233.2	119.8	2.7	10.71	2.2	4.5	2.1	6.6	59.7
W G A Kumarasinghe	1	RI 429	7.1	1.08	123.2	4.42	1.96	1.18	55	23	21	11.7	235.4	74.8	1.9	7.56	2.3	3.7	1.7	5.4	58.5
I M Rathnasiri	1	R2 429	6.89	2.29	301.0	8.91	4.44	1.23	78.8	84	36	10.0	207.5	109.5	3.2	14.58	2.0	7.2	3.6	10.9	61.1
W M Senavirathna Banda	1	R3 429	7.17	2.02	125.2	8.83	5.22	0.58	50.6	68	45	12.7	250.9	86.9	2.1	14.63	1.7	15.2	9.0	24.2	60.4
W M Kumarasinghe	1	R4 429	6.97	2.02	175.7	5.77	3.31	0.96	128.7	46	25	10.9	258.9	101.8	2.6	10.04	1.7	6.0	3.4	9.5	57.5
W Chathuranga Lakmal	1	R5 429	6.98	2.02	167.5	6.48	2.91	0.75	132	51	37	10.8	253.2	102.5	2.8	10.14	2.2	8.6	3.9	12.5	63.9
H A Lakshman Jayantha	1	R6 439	7.04	2.55	111.0	6.32	3.65	0.81	54.5	14	45	12.3	229.4	106.0	1.2	10.78	1.7	7.8	4.5	12.3	58.6
A W A Sunil Abesekera	1	R7 429	6.94	1.88	123.1	6.26	2.44	0.76	79.9	13	92	12.1	234.7	115.8	1.3	9.46	2.6	8.2	3.2	11.4	66.2
H Ratnasiri	1	R8 429	6.89	2.42	157.7	7.30	3.47	1.17	55.4	38	45	11.6	251.5	96.0	2	11.94	2.1	6.2	3.0	9.2	61.1
G G S Asanka Jayasinghe	1	R9 429	7.01	1.61	105.6	7.71	4.77	0.79	42.5	91	38	10.8	261.6	99.0	2.1	13.27	1.6	9.8	6.0	15.8	58.1
H P Upul Ranasinghe	1	R10 429	6.88	2.29	193.4	9.03	4.66	0.99	93.1	77	39	12.4	225.6	129.6	2.8	14.68	1.9	9.1	4.7	13.8	61.5
W M A Warnasooriya	1	W1 429	6.8	1.75	271	4.83	2.16	1.12	41.2	200	41	10.4	275.2	77.2	3.3	8.11	2.2	4.3	1.9	6.2	59.6
Chandani Swarnalatha	1	W2 429	6.92	2.29	155.6	6.68	3.37	1.15	121.7	231	48	9.6	255.5	120.9	4.7	11.20	2.0	5.8	2.9	8.7	59.6
S Kanthi	1	W3 429	8.14	1.48	179.8	6.62	4.84	0.84	299.9	40	34	11.7	178.6	113.7	3.0	12.30	1.4	7.9	5.8	13.6	53.8
D Renuka Dilrukshi	1	W4 429	7.37	2.55	124.9	7.11	3.16	0.92	63.5	109	37	11.6	242.7	103.9	3.9	11.19	2.3	7.7	3.4	11.2	63.5
D M C P Rajapaksha	2	W5 429	7.2	2.15	382.0	8.81	3.42	1.08	114.9	58	72	11.3	201.2	113.1	4.5	13.31	2.6	8.2	3.2	11.3	66.2
R A Ariyadasa	2	W6 429	7.18	2.42	95.2	5.92	2.3	1.09	65.4	30	60	12.2	267.7	108.6	2.2	9.31	2.6	5.4	2.1	7.5	63.6
E K M Dharmasooriya	2	W7 429	7.01	1.61	125.6	5.82	2.22	0.72	55.0	62	61	11.4	261.4	79.1	7.8	8.76	2.6	8.1	3.1	11.2	66.4
R M D I Rathgalla	2	W8 429	7.19	2.29	75.4	7.70	2.83	0.5	41.5	52	143	10.5	228.5	102.2	1.7	11.03	2.7	15.4	5.7	21.1	69.8
J M S K Jayasinghe	2	W9 429	7	2.02	108.3	7.43	3.37	1.1	51.1	81	71	10.7	276	85.1	39.6	11.9	2.2	6.8	3.1	9.8	62.4
P G Wijesiri	2	W10 429	6.98	1.21	67.0	5.16	2.02	0.54	58.7	35	52	8.9	246.9	69.2	2.5	7.72	2.6	9.6	3.7	13.3	66.8
W T L Warnasooriya	2	B1 429	6.77	2.29	274.0	7.50	3.56	0.82	99.7	14	67	10.1	230.9	101.6	4.5	11.88	2.1	9.1	4.3	13.5	63.1
W M S K Jayalath	2	B2 429	7.13	2.02	80.6	6.22	2.39	0.75	42.1	14	51	8.5	221.7	77.2	1.4	9.36	2.6	8.3	3.2	11.5	66.5
R M R Ajith	2	B3 429	7	2.02	146.8	7.74	3.46	0.99	83.3	39	55	10.8	210.8	114.2	1.9	12.19	2.2	7.8	3.5	11.3	63.5
B M S Hemantha	2	B4 429	6.98	1.61	150.8	8.2	3.39	1.07	50.8	58	45	1.3	256.7	94.8	35.8	12.66	2.4	7.7	3.2	10.8	64.8
D M Dharmapala	2	B5 439	6.84	1.08	153.6	8.01	3.77	0.66	67.6	56	55	9.5	264.3	68.3	2.2	12.44	2.1	12.1	5.7	17.8	64.4

Interprettion

Large number of sites low in S
Zn extremely low
Ca/Mg very low in all sites
Ca Saturation low in some sites

Fertilization:

N as required by the crop
CaSO4 required for ratios and for S
Foliar applications of Zn

Kg/ Plot/ Application	Initial	Mid	Late
Urea	0.17	1.34	0.78
$CaSO_4$	0.97	0.69	0.97
Application per week		2	
Phosphoric Acid (ml) *Application every two week*	48.4	35.6	48.4
Foliar application of micronutrients is required weekly, especially Zn			

Table 9 : Fertigation Recommendations per Application per Half Acre Plot