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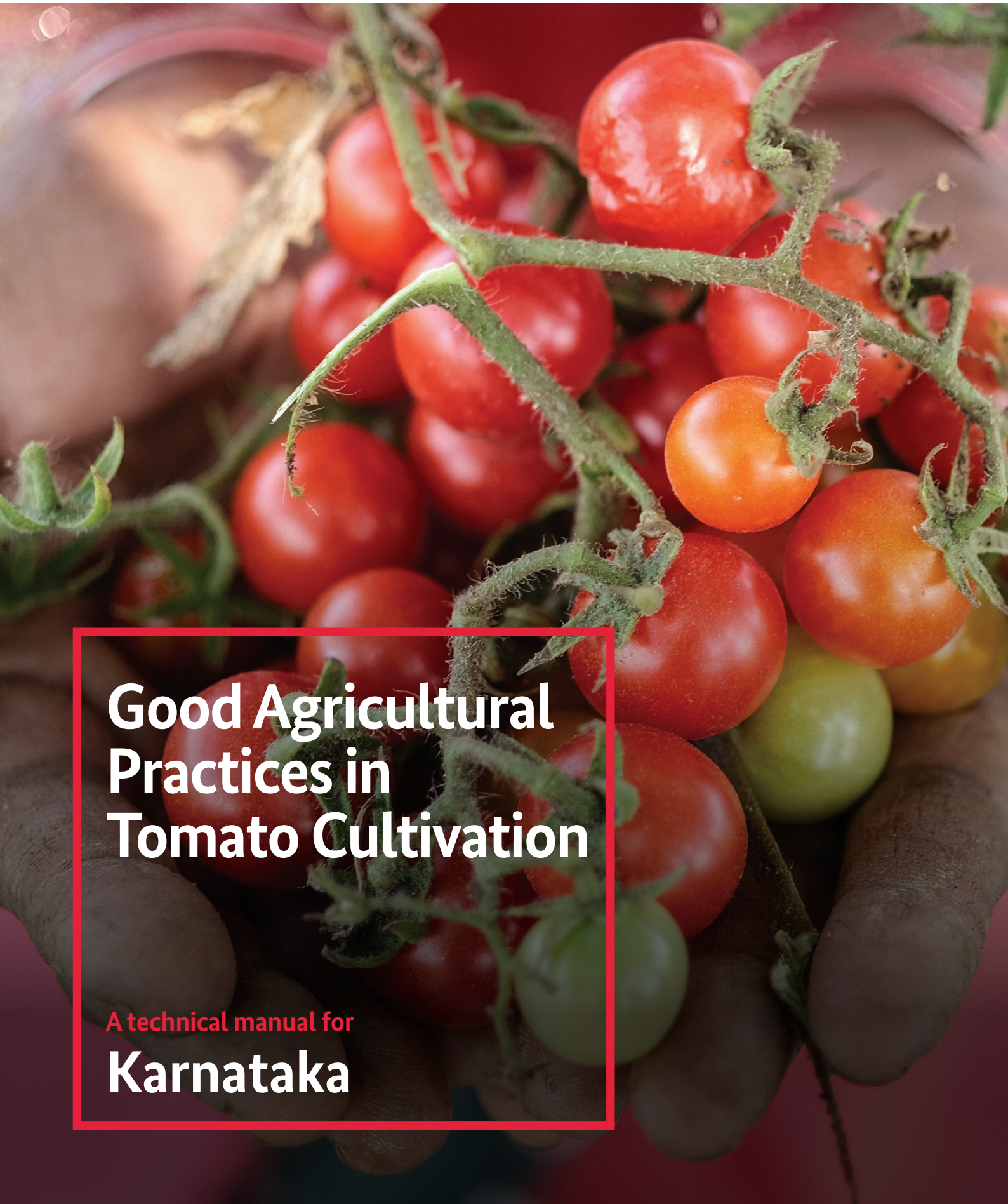

Good Agricultural Practices in Tomato Cultivation

A technical manual for Karnataka

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GOOD AGRICULTURAL PRACTICES IN TOMATO CULTIVATION

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Foreword from GIZ

The global programme "Green Innovation Centres for the Agriculture and Food Sector (GIC)" in India, commissioned by the German Federal Ministry of Economic Development and Cooperation (BMZ), has been working on the integrated development of the tomato, potato and apple value chain by identifying and scaling innovations that enhance the productivity and income of smallholder farmers and small-scale farming enterprises while creating employment opportunities in up-stream and down-stream businesses. The project is being implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, in cooperation with the Ministry of Agriculture & Farmers Welfare (MoA&FW).

In Karnataka, the GIC project has been working on the potato and tomato value chain in Hassan and Chikkamagaluru districts. This project is being implemented through a dedicated field team and in close cooperation with the Department of Horticulture (DoH), University of Horticultural Sciences Bagalkot (UHSB), Krishi Vigyana Kendra (KVK), Centre of Excellence for FPO, etc. The project has successfully demonstrated several innovations to achieve the key objectives. By applying the Participatory Technology Development (PTD) approach, the GIC project tested and implemented various innovative practices together with the farmers on the fields to address common challenges in the value chain.

Tomato farmers are confronted with low yields and income levels, which are often caused by a lack of access to quality seedlings and insufficient use of good agricultural practices. To address these challenges, the GIC project has worked with tomato nurseries to produce healthy seedlings. Many small but effective measures have been introduced in these nurseries and both nursery owners and farmers have been trained importance of producing and using of healthy seedlings.

Fluctuating market prices for tomatoes is one of the key challenges faced by the farmers. This trend has been continuing since several years and finding solutions to solve this is a challenge. The project has introduced a staggered planting system as one solution. Additional work has been done on an experimental basis developing processing or dual-purpose varieties by collaborating with tomato seed companies and processing companies in cooperation with the World Vegetable Centre.

Integrated pest management practices were also given importance along with effective soil management practices. All these innovations have resulted in enhancing the yield level and farmers' income despite many climate-related challenged observed. As the GIC is now entering a new project phase, it documented all promoted good practices in the form of a technical manual which can serve as a ready reckoner for extension officers and farmers. This document is prepared with the involvement of the University of Horticultural Sciences Bagalkot and the Department of Horticulture but most importantly with the constant involvement of the tomato farmers in Karnataka. I sincerely thank all these organisations for contributing their learnings.

I hope that this technical manual for good agricultural practices will help to scale up sustainable agricultural practices in tomato cultivation in Karnataka.

G. Qualitz

Mr Gerrit Qualitz
Project Director
Green Innovation Centres for the Agriculture and Food Sector – India

Message from University of Horticultural Sciences, Bagalkot

India is the world's second largest tomato producer both in terms of area and production with 0.8 million ha and 20 million tonnes respectively. In India, it is being cultivated as commercial crop in the states of Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu etc. In Karnataka, Kolar, Chikkaballapura, Dharwad, Belagavi, Chikkamagaluru, etc. are the major tomato growing districts.

The yield level of the crop is about 25 t/ha. Farmers follow very intensive cultivation practices with anticipation of higher yield and better prices for the produce, but rarely these two factors match and most of the time farmers will be incur huge losses.

To overcome these problem, innovative cultivation practices are needed with relay of integrated approaches. GIZ has brought in many innovations such as good agricultural practices with focus on agroecological approaches, balanced nutrition management, use of improved sprayers, staggered planting practices, wider spacing etc. The Green Innovations Centre for the Agriculture and Food Sector (GIC) India project has collaborated with University of Horticultural sciences, Bagalkot (UHSB) and Karnataka State Department of Horticulture (KSDH). The collaborative efforts of UHS, GIZ and KSDH has impacted greatly on improving the yield level and income of the farmers.

In this context, GIZ India under the Green Innovations Centre for the Agriculture and Food Sector (GIC) India project compiled the innovative and good agricultural practices of tomato production in the form of this manual. Also, they are bringing out manual of good agriculture production in potato and local potato seed production through Rooted Apical Cutting (ARC) technology. I hope this manual will help all the stakeholders of the farming community to improve their income and sustainable development in horticulture sector.

My best wishes and congratulations to whole team.

Dr. K. M. Indiresh
Vice-Chancellor,
University of Horticultural Sciences,
Bagalkot, Karnataka

Message from Department of Horticulture, Karnataka

Tomato, one of the top crops in Karnataka alongside Onion and Potato, is widely cultivated in different districts. While hybrid varieties have increased tomato yields over the past fifteen years, farmers are often beset by climate and market-related challenges that can result in significant losses.

Cultivating tomato is a labor- and input-intensive process that demands considerable investment, and with rising input and labor costs on one end and fluctuating prices in the market on the other, tomato farming can feel like a gamble.

To mitigate these risks, the adoption of sustainable practices is crucial. Since 2017, GIZ India under the Green Innovations Centre for the Agriculture and Food Sector (GIC) project is working with farmers in Kadur in Chikkamagaluru district to promote sustainable farming practices with a strong emphasis on healthy seedlings in nurseries. As the GIC project nears completion in Karnataka, the compilation of these best practices from nurseries to the field to harvesting in the form of a manual is a commendable effort. This manual is a collaborative effort with the University of Horticultural Sciences, Bagalkot and Department of Horticulture.

This comprehensive collection of good practices will serve as a valuable reference for extension staff and farmers to promote sustainable farming practices in tomato cultivation.

Mr Rajender Kumar Katari
Principal Secretary of Government
Karnataka Government Secretariat
Horticulture & Sericulture Department

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INTRODUCTION

Tomato (*Lycopersicon esculentum Miller*) **belongs to the genus Lycopersicon under the Solanaceae family.**

It is an herbaceous plant that grows between 1-3 m in height with a weak woody stem. The flowers are yellow in colour and the fruits of cultivated varieties vary in size from cherry tomatoes, which are about 1-2 cm, to large-sized tomatoes, which are about 10 cm or more in diameter. Originating in Peru and Mexico, it was introduced to India by the Portuguese. In India, it is being cultivated as a commercial crop mainly in the states of Andhra Pradesh, Karnataka, Maharashtra, Odisha, West Bengal, Tamil Nadu and Madhya Pradesh. The total area under tomato is 814,000 Ha with a production of 20.51 million tonnes (2018-19) . The average productivity of tomato is about 25.2 t/ha. India is the world's second-largest tomato producer both in terms of area and production. The area, production and productivity of tomatoes are on an increasing trend for the past 10 years, which signifies the importance of this crop both for farmers.

Almost all the tomato produced in India is of table-purpose variety which is used mainly for cooking. The true processing type of tomatoes are hardly grown in India. Processing industries use the hybrid varieties with higher Brix and lycopene content for making sauces, puree or ketchup, etc.

It generally grows well in hot and dry climates with well-drained soils. The optimum temperature for the fruit set is between 18°C and 26°C. Above 35°C, the fruit set is reduced. Temperatures above 40°C affect the plant's growth and fitness negatively. Although tomato is a winter season crop, it can be cultivated in any season using proper management.

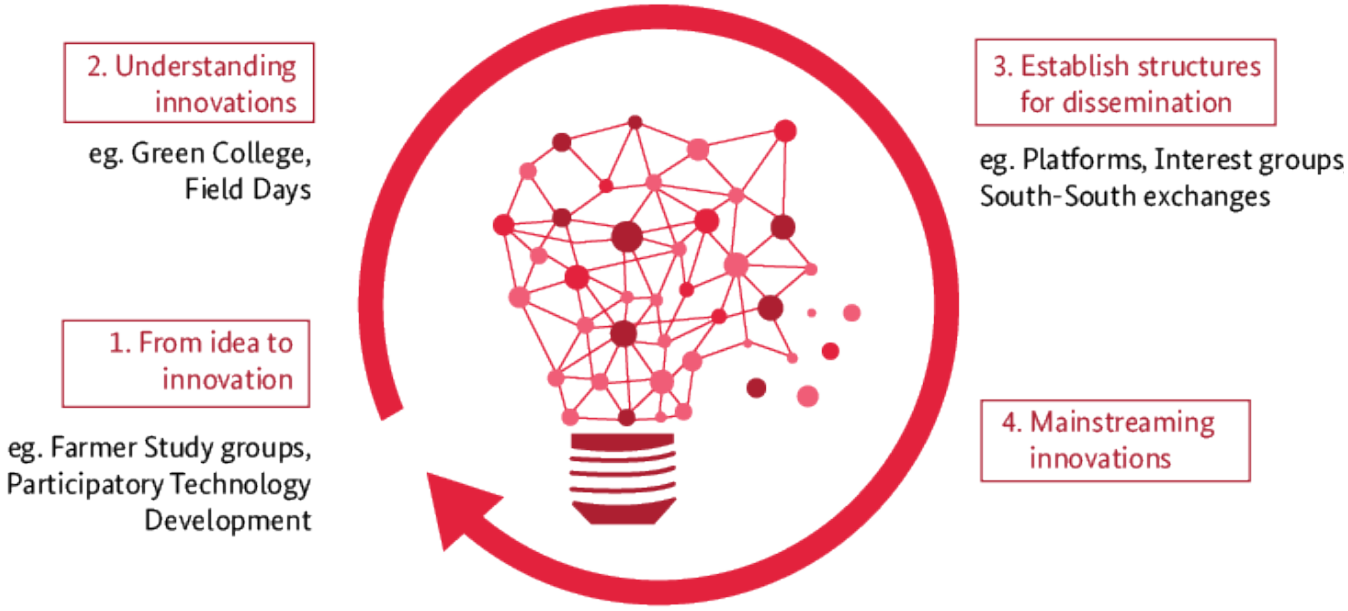
In Karnataka and Andhra Pradesh, generally, tomato plants transplanted between December and March provide good reliable marketable yields because of the favourable weather conditions and a low incidence of pests and diseases. However, with different adapted conditions and varieties available, today tomato has been growing everywhere around the globe.

The tomato crop is also referred to as a "gambling crop" among the farmers because the prices fluctuate from Rs. 1/kg to nearly Rs. 100/kg. Despite such unpredictable price trends, farmers tend to go for planting whenever the price soars in the market in anticipation of the same bumper prices for their produce when they harvest. However, due to gluts in the market, most of the time the farmers realise very low prices for their produce, which do not cover the costs of cultivation. But, whenever the farmers realise a good price, they realise a very good profit which will compensate for the loss they had incurred in previous seasons. This has kept the farmers in a gambling situation. To reduce the risk of such a gambling situation, farmers are required to focus on adopting good agricultural practices, through which the costs of cultivation can be reduced, and yield can be enhanced.

The **Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH** is a public-benefit federal enterprise of the German Government. In its projects, GIZ works with partners in national governments as well as actors from the private sector, civil society and research institutions. GIZ's main commissioning party is Germany's **Federal Ministry for Economic Cooperation and Development (BMZ)**. Other commissioners include the European Union, the UN, the private sector, and governments of third countries. The global programme **"Green Innovations for the Agriculture and Food Sector (GIC)"** is funded through the Special Initiative "Transformation of Agricultural and Food Systems" of the BMZ. Since 2016, the project is implemented in India by GIZ in cooperation with the **Ministry of Agriculture & farmers Welfare (MoA&FW)**.

Working in Kadur region of Chikmagaluru district, the GIC project identified, tested and introduced various innovations in a participatory manner involving the farmers. The project has adopted the Participatory Technology Development (PTD) process to identify the innovations and to work on those which are accepted by the farmers. Technology Development (PTD) process to identify the innovations and to work on those which are accepted by the farmers.

This report is a compilation of good agricultural practices and innovations introduced to the farmers to enhance their net productivity and income level. While preparing this report, inputs from the University of Horticultural Sciences, Bagalkot and the Department of Horticulture were taken. Scientists and officers from these institutions participated in a three-day write-shop to prepare this report.



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The sustainable practices are documented in a simple and easy-to-read/understand manner. The target groups of this report are both extension workers and farmers. To make it more comprehensive, all the stages of the crop – right from the potato seed tuber purchase to seed treatment and the field level cultivation aspects along with post-harvest practices, will be discussed. Also, suitable agroecological approaches are included, especially for soil fertility management and integrated pest and disease management.

Following are the broad sections of this report:

- Nursery management
- Tomato cultivation in the field
- Land preparation
- Irrigation and water management
- Mulching
- Seedling handling and transplanting
- Nutrient management
- Canopy management and staking
- Weed management
- Pest and disease management
- Spraying techniques
- Harvesting, grading and transportation

Lastly, an indicative cost of cultivation and a case study is included.

While preparing this document, existing manuals, Package of Practice of the university and other relevant knowledge products are referred to and acknowledged.

Some of the key manuals and reports referred to are:

1	Tomato Manual prepared by HEEU CoH, Mysuru
2	Vegetable nursery and tomato seedling management guide of WorldVeg
3	Field-grown tomato production technology guide of WorldVeg
4	Project reports, materials, and manuals submitted by AFC to GIC project
5	Package of Practices published by Agricultural Universities of the States
6	IPM and IDM information published by NIPHM
7	Technical bulletins published by WorldVeg
8	Technical bulletins published by IVRC
9	Technical bulletins published by IIHR
10	Technical bulletins published by NHRDF
11	Technical bulletins published by NABARD

NURSERY MANAGEMENT

01

A nursery is a place or an establishment for raising or handling of young seedlings until they are ready for more permanent planting.

The production of healthy seedlings plays a vital role in the establishment of a healthy crop in the main field. In the past, farmers themselves produced the seedlings required for transplanting at a lower cost, as most of the vegetable varieties were open-pollinated types. Now, most commercial farmers are going for intensive vegetable cultivation using hybrids to augment productivity. As these hybrid seeds are expensive, converting every individual seed into a healthy seedling becomes essential which requires intensive nursery management.

Some of the problems observed in traditional nurseries that can lead to lower yields are as follows:

- Improper structures (e.g no insect proof net or double doors)
- Higher pest and disease incidence (such as damping off)
- Poor germination due to improper management of moisture in beds
- Missing the right growing season due to delays in transplantation, particularly in rainfed farming
- Lack of awareness of improved nursery practices such as raised beds, seed treatment or protection against the environment.
- Availability of seedlings throughout the year

Structural Aspect of a Nursery

Seedlings must be grown under a cover with proper protection. There are three choices for the type of cover:

Polyhouse

A polyhouse structure riveted with galvanized nuts and bolts is generally recommended as it will be stronger and easier to repair if it is damaged.

Suggested specifications for the structure are as follows :

- The width of a single span of the polyhouse should not exceed 26 ft (8 m).
- The roof structure should be extended at least 2.4 ft (0.75 m) on all four sides of a polyhouse to drain off rainwater in heavy rainfall areas.
- The complete structure should be made of 2 mm
- thick and 2.8-2.9 inches in diameter galvanized steel tubular pipes.
- The gutter height should be at least 15 ft above the floor area.
- The gable needs to be covered with insect proof net (preferably 40 mesh or more) to prevent insects entering the polyhouse from roof besides ensuring fair ventilation.
- The height of the curtain wall or apron should not be beyond 1 foot from the ground level.
- Movable iron tables arranged contiguously with 3 ft (1 m) working space in between on which to place the seedling trays are ideal to prevent contact of seedlings with the soil.
- The length and breadth of each table could be 11 x 6 ft (3.5 m x 1.75 m), so that two rows of tables could be arranged in a single span of the polyhouse leaving a working space of 3 ft in between.
- Bamboo benches that can last for at least 1.5-2 years may be used wherever bamboo is readily available.
- A double door system that closes automatically is recommended with 6 ft (2 m) spacing between the doors. Doors should be sliding, not swinging to ensure there is no gap while closing. To ensure

there are no holes or gaps in doors to allow insect entry, insert rubber flaps or brushes in the gaps.
- The side walls should be made of insect-proof net and the top to be covered with plastic to prevent rainwater from entering.

Nethouse

Here, the entire structure is covered with a 40 mm mesh. A nethouse is recommended in dry regions where high rainfall and humidity are not a problem. This structure is suited when the investor requires a lower cost structure that still provides complete protection from pests and diseases.

Some key aspects to be considered are:

- This structure should not be less than 13 ft high.
- Galvanized steel pillars 2-2 .2 mm thick and 2.8-2.9 inches in diameter will usually withstand a wind velocity of up to 140 km/h.
- UV stabilized insect-proof net with 40 mm mesh is generally recommended. For smaller structures and in cooler areas, 50 mm and 60 mm mesh can be used and this provides better insect exclusion.
- Red, silver or white shade nets can be used, but not green. Green coloured nets cut off more light.
- When seedlings are grown in nethouses, it is important to protect the seedlings from rainwater. Metal hoops must be fixed over the raised beds and a polythene sheet is fitted over the hoops and fixed at one end of the raised bed. It is spread over the beds during rain.

Shade Nethouse

This is a very low-cost structure recommended mainly in very dry regions. Shade netting is available on the market in many densities such as 25%, 30%, 35%, 50%, 60%, 75% and 90%. Here, insect proof net of up to 6-8 ft is recommended for side walls.

For all kinds of nurseries, light management is most important. Improper light management affects plant growth. Bright ambient sunlight must be reduced by using shade netting to get the right light intensity for proper growth at different seedling stages.

Other important structural aspects to be considered are:

- Double door system to prevent the entry of the insects.
- Table or raised bed to avoid water stagnation.
- Provision of weed matting: Weed matting is a dark thick woven plastic mesh that prevents weeds from germinating but allows water through. It should be used to cover the entire nursery area.

Cocopeat and Other Media

Growing seedlings in an artificial medium without soil or compost is healthier as it prevents contact with soil-borne diseases. Drainage also can be easily varied in artificial media. Perlite, vermiculite and peat moss are expensive. Cocopeat is a cheaper and effective alternative base for an artificial growing medium, but it is important to get the pH right and avoid any salt contamination. Cocopeat is the pith derived from coconut husks after the removal of fibre by the coir industry.

The recommended pH of coco peat is 5.8-7. Highly acidic or alkaline coco peat will hinder seedling growth. It is suggested to test the pH of the cocopeat with a pH meter before using it. It is always better to sieve the cocopeat. Instead of raw cocopeat alone as a medium, a mixture of cocopeat, vermiculite and perlite in the ratio of 3:1:1 by volume is better for the growth of vegetable seedlings. Vermiculite or perlite not only reduces the weight of the medium but also provides better drainage and porosity to the medium, enhancing the growth of young roots.

Salinity is measured as Electrical Conductivity (EC). The EC of cocopeat should be less than 1 mS/cm. If the EC is higher, the seedlings grown in this media will be weak and lanky, and the EC needs to be reduced by either adding buffering chemicals (may be done by the supplier) or simply by repeated washing at the nursery level.

Biological Enrichment of Cocopeat to Reduce Pests and Diseases

Cocopeat or any similar substrate can be enriched to reduce pest and disease problems in seedlings by mixing the following biological additives into each tonne of substrate:

- Neem cake at the rate of 50 kg
- Metarhizium anisopliae at the rate of 5 kg
- Trichoderma harzianum at the rate of 2 kg
- Pseudomonas fluorescens at the rate of 2 kg

These additives act as insecticides, fungicides, bactericides or nematicide and can be particularly useful for producing healthy seedlings of tomatoes.

The Indian Institute of Horticultural Research (IIHR) in Bengaluru has developed mass production techniques for a range of other biological agents that when mixed with substrates can reduce pest and disease problems more safely and economically than using chemicals. Similar products are available with all Farm Universities as well as State Department of Horticulture, too.

The following patented bio-pesticide formulations available as wettable powders (WP) can be used to treat cocopeat in which seedlings are grown under shade net or protected cultivation.

The recommended dosage is:

- 5-10 g of formulation/kg of cocopeat
- Pseudomonas fluorescens 1% WP (an effective bio-bactericide with nematocidal properties)
- Trichoderma harzianum 1% WP and Trichoderma viride 1.5% WP (effective bio-fungicides with nematicidal properties)
- Paecilomyces lilacinus 1% WP and Pochonia chlamydosporia 1% WP (effective nematicides)
- Use of Metarhizium anisopliae 1% WP is under experimentation as a bio-insecticide and found promising in the initial trials

Seedling Trays

Plastic seedling trays (also known as pro-trays) of different sizes are available in the market. The selection of the seedling tray size by the nursery owner depends on local farmers' preferences, but mostly, trays with 98, 102 or 104 cavities are preferred.
There are two types of cavities in the trays available in the market: inverted cone-shaped, and inverted pyramid shaped. The experiences of nursery entrepreneurs indicate that a tray with 104 cavities with an inverted pyramid shape is ideal for a strong stem and good root growth as it provides a wider space for the root system to grow. In contrast, the inverted cone shape narrows down the space for roots to spread, resulting in a cluster.

A seedling with a strongly developed tap root and secondary roots will establish in the main field faster than a seedling with a clustered root system.
The size of each cell is 25 mm long x 25 mm wide x 32 mm deep, and the hole at the bottom of the cavity should not be less than 2 mm wide. Ideally, 25-40 cm of growing medium is required to fill each cavity.

Water and Weed Management

Water quality is important and can have a big impact on the health and growth of seedlings. The most common water quality problems are from salts, particularly when borewell water is used. Water quality is measured by EC and pH.

The ideal ranges for these are:

- EC should be below 1 mS/cm. Seedling growth may be affected badly if the water EC is high.
- pH of the water should be 6.5-8.4. Higher pH levels are associated with higher levels of salts that will damage seedlings.

An EC meter and pH meter need to be installed in all nurseries.

A lower EC (less than 1 mS/cm) is always preferable. No correction will be required. If the EC is too high, there are several options to reduce the problem:

- A rainwater harvesting structure may be constructed to mix rainwater with groundwater to reduce the EC.
- Water softeners (such as potassium chloride) with bactericidal properties may be used to reduce water EC. (Caution: Do not use sodium chloride to soften water, as it is toxic to seedlings!).
- Good drainage in the seedling trays can prevent the build-up of salts, even when the EC is not initially ideal.

Suggested time and frequency of irrigation:

- It is best to irrigate in the morning. If seedlings are irrigated in the evening, water droplets will remain on the leaves and lead to fungal infections. If the growing medium is porous, less water is required.
- Water two or three times a day depending on weather conditions. During damp weather, irrigation can be reduced to once a day. If drooping of seedlings is noticed, water immediately.
- Reduce watering in the last week to assist in hardening of seedlings prior to transplanting
- Experienced labour should do the watering because they understand when to water and how much water is required. Excess watering leads to fungal problems.

Weed Management

The nursery and its surroundings must be weed free. This is because weeds can host pests and diseases that can attack the seedlings. Weed matting should be used to cover the entire nursery area.

Nutrient Management

Fertilizers are not added to the growth medium, but nutrients are supplied to the growing seedling in the artificial medium through fertigation or spraying every day. Daily application of 19:19:19 containing micronutrients at the rate of 5 g per 10 litres of water, starting from the cotyledon stage till 16 days and gradually increasing the dosage every 3-4 days from 16-24 days, and then later stopping for hardening.

Pest and Disease Management

Pest and disease problems can be minimized by careful construction and maintenance of the protective nursery structure. Some general precautions will help in reducing the number of sprays:

- Closing the doors properly without any gaps to exclude insects
- Repairing holes in the net whenever noticed
- Avoiding excess irrigation that promotes diseases
- Disinfecting the trays, nursery tools and nursery area
- Sterilizing the growing medium
- Installing sticky traps in between the two doors to catch any insects that do enter Prophylactic sprays may be needed if seasonal conditions or local outbreaks suggest a potential problem.
- When pests and diseases are noticed, a quick application of biopesticides or mild chemicals is needed.

Using sticky traps for monitoring and trapping insects

Sticky traps are an important part of an Integrated Pest Management (IPM) programme. They are easy to implement and inexpensive. Sticky cards will trap the adult stages of flying insects such as thrips, whiteflies, leaf miners and winged aphids. Remember, immature stages of thrips and white flies will not be caught on the cards.

Yellow sticky trap

Yellow sticky traps are best for general pest monitoring. It attracts whiteflies, leaf miners and winged aphids.

Blue sticky trap

It attracts thrips, hence used to detect thrips population.

Age of seedlings: A seedling that is 25-26 days old with 4-5 true leaves is at the right stage for transplanting.

Overall characteristics of good nurseries are:

- Double door system and 40 mesh UV stabilised insect-proof net to prevent the entry of leaf miner, white flies and thrips.
- Use of high-quality coco peat to increase germination rate from 70 to over 95%.
- Weed mats to prevent nematodes, Tuta absoluta and serpentine leaf miner.
- Improved water management.
- Improved light management from low at germination to high intensity at 15 days.
- Hardening area fenced by 10 ft high insect netting.

Do's	Don'ts
✓ Go for double door system	✗ Spraying without protective clothing
✓ Prepare raised beds	✗ Work on a tarpaulin sheet
✓ Install EC meter and pH meter	✗ Do not dump waste near the nursery
✓ Arrange the plastic crates properly in the transport vehicle	✗ Do not leave gaps in the structure
✓ Ensure no gaps in the polythene cover	✗ Do not fold the seedling trays in the crate
✓ Pack the seedling trays in plastic crates	✗ Do not let water stagnate in and around the nursery
	✗ Do not leave holes in the insect net
	✗ Do not allow weeds to grow at the nursery boundary
	✗ Do not leave gaps while spreading weed mat that may lead to weed emergence
	✗ Do not keep the door open
	✗ Do not allow the seedlings to come into contact with the soil
	✗ Do not allow other plants to grow inside the nursery structure
	✗ Do not dump unused material inside the nursery structure
	✗ Do not damage seedlings due to improper packing
	✗ Do not stack the sown seedling trays tightly
	✗ Avoid black shade net under the roof during the winter months

TOMATO CULTIVATION IN THE FIELD

02

Key Problems in Tomato Cultivation are:

- Poor quality nurseries leading to diseased seedlings being planted.
- Poor land preparation leading to flooding and poor root development.
- Imbalanced nutrient management leading to poor quality fruits and low yields
- Poor transplanting practices leading to high mortality percentage (up to 20%)
- Overuse of water leading to root diseases
- Overuse of chemicals for Pest and Disease management leading to extra pest pressure and high production and environmental costs
- Low organic matter in the soil

Tomato cultivation is under pressure because of groundwater decline, erratic rainfall and volatility of prices.

Selection of Varieties

There are two types of tomato varieties based on their growth habit. They are:

Determinate Varieties

They have a determined height and grow 2-3 ft tall (60-90 cm), then stop growing and have one determined time of flowering, fruit set and fruit development.

They are bushy in appearance and the entire crop ripens in a short window of 4-6 weeks, so they are normally harvested in a short window of 45-60 days. The fruits can be easily picked and are suitable for open field conditions.

Indeterminate and Semi-determinate Varieties

These varieties keep on growing until they are killed by disease. The plants set and ripen fruit continuously, which means that the harvest season can extend for many months and the total yield from a single plant can be very large. In good conditions, indeterminate tomato plants can grow up to 30 ft tall (10 m). These are most suited for cultivation under protected conditions and are not recommended for open-field cultivation.

Another way of classification of tomato varieties is based on their use. Here also, there are two broad categories:

Fresh Market Types or Table Purpose

In India, most of these tomato types are acidic, round or oblong and suited to use in cooking or salads. Consumers of fresh market tomatoes prefer familiar-looking varieties and expect specific quality attributes, such as taste and texture. With a good harvest and post-harvest handling, these varieties are appropriate for high-value markets.

Processing Types

These have a deeper red colour and a higher solids content than fresh market types, as they are the most important quality attributes in the processing industry. However, dark red tomatoes with a firm texture can be very attractive for the fresh market as well as for processing.

Therefore, they are often called “dual-purpose” varieties. At present, there are very few of these grown in Karnataka, but there is a rapidly expanding market for such types in India.

Therefore selecting the right varieties/hybrids as per the climate and the region is crucial.

Some of the seasons and region-specific varieties recommended by the university are as below:

Variety	Characteristics
Hybrids	
Arka Ananya	It is known for its resistance to the Tomato Leaf Curl Virus and results in yields of about 65-70 t/ha.
Arka Rakshak	It is a very high-yielding hybrid and produces 75-80 t/ha. It is resistant to leaf curl virus, nematode, and leaf spot diseases. It produces dark green foliage and protects the fruits from sun burning. The first harvest comes in 65-70 days. The fruits are of medium size with round a shape and flat surfaces on both ends. Each fruit weighs about 80-90 g and has firm dark red skin. Hence, it has a good keeping quality (up to 25 days from harvest) and is ideal for distant markets and good for processing.
Arka Samrat	It is an F1 hybrid and resistant to triple diseases viz. Leaf Curl Virus, Nematode and Leaf Spot. It is a semi-determinant type and the first harvest can be done in 65-70 days after transplanting. On average each fruit weighs 90-100 g and the yield will be 80-85 t/ha. The fruits are dark red in colour and have firm skin, they hence demonstrate good keeping quality. Arka Samrat can be grown in all seasons.
Varieties	
Megha L-15	It is an open variety suitable for high-temperature areas. Fruits are of medium size and with medium keeping quality. They can be stored for 8-10 days after harvest. The yield level is 25-30 t/ha.
Arka Vikas	This variety is suitable for rainfed areas in Karnataka. The overall duration of this variety is 140 days, and its yield level is about 35-40 t/ha. The fruits are medium-sized (80-90 g) with thick red skin.
Arka Abha	It is a medium-duration variety with 140 days duration. This variety has resistance to nematode disease and is suitable to grow in the rainy and winter seasons. It bears small to medium-sized fruits (75 g) and its yield level is about 40-43 t/ha.

Variety	Characteristics
Varieties	
Arka Ashish	This is a short to medium-duration variety (130 days) and produces oval-shaped fruits. It has good cluster-bearing characteristics with uniform maturity of the fruits. Hence, it is suitable for processing. Arka Ashish is resistant to powdery mildew disease and suitable to grow in the rainy and winter seasons. The yield level is about 38 t/ha.
Vaibhav	This heat¬-tolerant variety with a high yield level (45-50 t/ha) is resistant to viral diseases and nematodes. It is suitable for long-distance marketing as it has a good keeping quality due to its thick skin.
Abhinav	Semi-determinate with vigorous plant growth with broad leaves and excellent foliage cover. Fruits will be very firm with good keeping quality. Fruits are in square shape and medium sized (80-100g). Fruit harvesting will start 60-65 days after transplanting. Fruits will ripe uniformly with attractive deep red and glossy colour.
US-440	It is a determinate type and the. first harvesting starts 60-65 days after transplanting. Fruits are very firm fruits with flat round shape, medium size (80-100 g) and excellent shelf life. It is tolerant to tomato leaf curl virus and heat.
PHS-448	This is a semi-determinate plant of long duration with good foliage cover. The first harvest will start from 60-65 days after transplanting. The fruits are rectangular, square, and oval red and each fruit will weigh 90-100 g. The fruits are very firm and good for shipping. They have an intermediate tolerance to bacterial wilt and tomato leaf curl virus.

LAND PREPARATION

03

Soil is a very important factor in agricultural production. It provides space for the roots, which give the physical hold to plants and work on water and nutrient uptake and gas exchange.

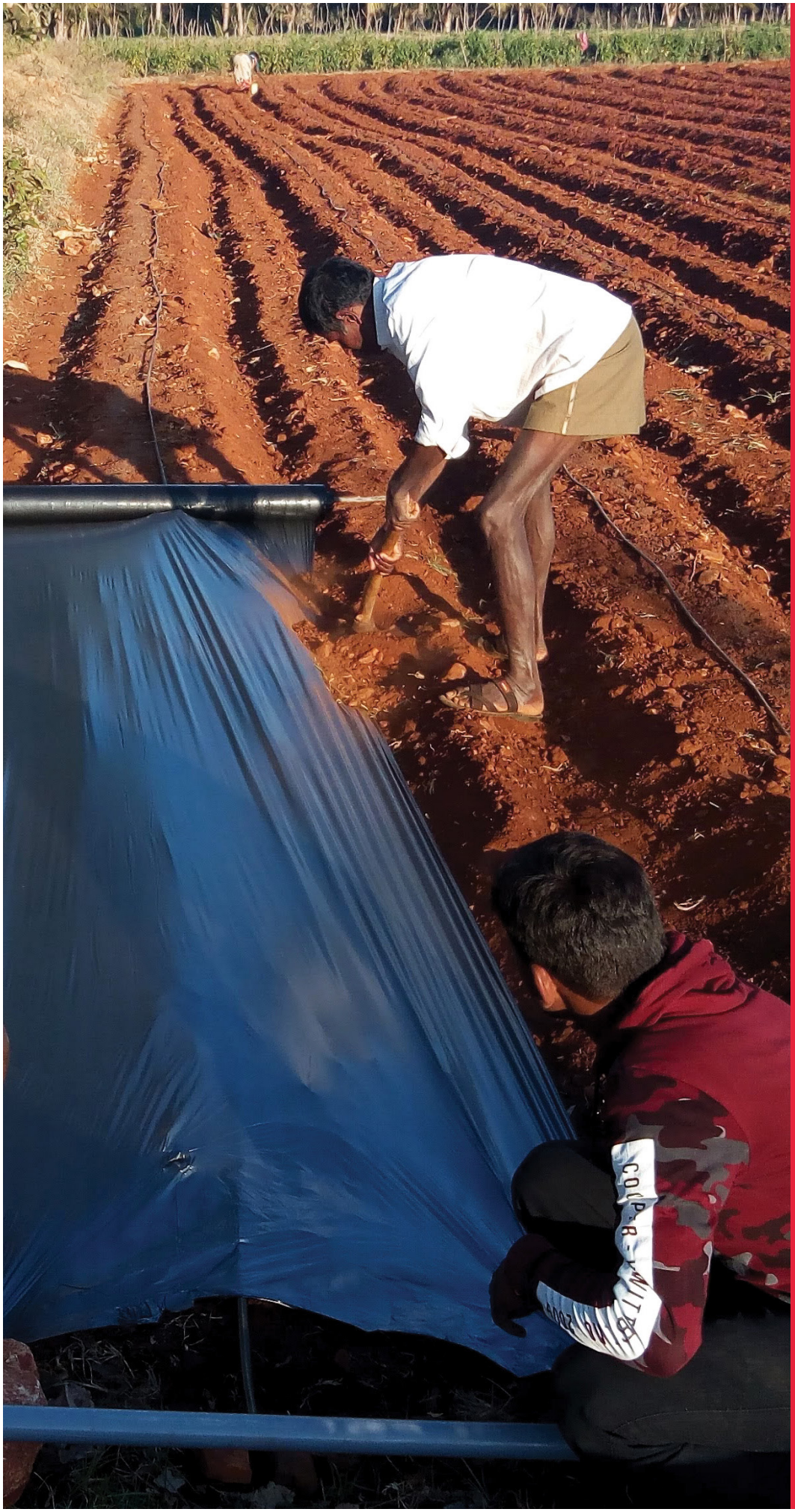
During the early development of the plants, loose topsoil supports root growth. A slightly recompacted subsoil then gives a good hold for the bigger root system and is a good storage for water and nutrients.

A finely tilled light clay textured soil is preferred in summer to retain moisture for a long period. In the rainy season, lighter sandier soils are preferred to allow good drainage of excess water.

Raised beds of 3 ft (100 cm) wide and 1 ft (30 cm) high are recommended with 4 ft (120 cm) in between the adjacent beds. Raised beds are particularly important if transplanting takes place during the rainy season.

Irrigation and Water Management

Frequent irrigation is essential for optimum plant growth, fruiting and yield. The crop should be irrigated at an 8-12-day interval. However, in summer, more frequent irrigation is required due to higher surface evaporation. Generally, farmers follow the open-furrow method of irrigation. However, drip irrigation methods should be followed which is highly economical and produces quality tomatoes. Through drip irrigation, fertilisers can also be given.



MULCHING

04

Mulching is an effective protection against weeds, besides soil and soil moisture conservation/ utilisation.

Generally, the application of plastic mulch suppresses weeds after planting, at least to the point that the fast-growing tomato plants will outcompete weeds in search of light. Manual removal of individual weeds protruding from the mulch may be more advisable and not more labour-intensive than herbicide application.

Mulching is the process of covering the soil around the plants to improve plant growth. It has multiple benefits for the growing crop and can later protect leaves and fruits from coming in direct contact with the soil besides preventing many insect pest stages from entering soil for pupation. Mulch is a thin layer of any substance spread over the soil near the plant's root zone. A range of different mulches can be used, but the most common are organic and plastic mulches. Efforts are on to explore the potentiality of saris (cotton and/ polyester) as mulch which can offer multiple effects (light/heat/pest absorption/repulsion) beyond weed, moisture and air management.

Organic mulches are biodegradable. They stay in place for one cropping season, performing as a protective layer. After the cropping season, they are typically incorporated into the soil by basic tillage and to add some nutrients and organic matter to the soil. Farmers usually use farm wastes such as dried leaves, fallen branches, hay, grass, finely cut and dried bark, jowar trash, paddy husk, sugarcane trash, dry coconut leaves, coconut/arecanut husk and composts etc., to maintain micro-climatic conditions congenial for good plant growth. Traditionally, farmers have been using organic materials such as mulch. The benefits are that they keep soil temperatures cool, and they are inexpensive, natural and biodegradable. The disadvantages are a lack of sufficient material to cover large crop areas and the danger of spreading pathogens through any undecomposed plant wastes applied near the root zone. It is, therefore recommended not to use organic mulch originating from tomato, chilli or brinjal plants in tomato production.

The most common one used is all black, but this is gradually being replaced by black and silver-coloured plastic sheets. Different colours have an influence on light absorbance and reflectance and therefore influence the temperature of the soil underneath.

Raising seedlings in cocopeat

Advantages and disadvantages of different plastic mulches are listed below:

Black Mulch	White Mulch
Black plastic mulch absorbs most incident solar radiation, including visible, infrared and ultraviolet light. Although much of the heat absorbed is lost to the atmosphere through convection and re-radiation soil temperatures will be increased under black mulch and it is therefore not recommended during summer months. As black film does not allow the sunlight to pass through, it stops weed growth by preventing photosynthesis, unless germinating weeds (e.g. nut grass) are strong enough to penetrate the plastic film.	Light is reflected into the atmosphere or the plant canopy from a white plastic mulch, resulting in slightly cooler soil temperatures (-1°C at 2.5 cm depth). White plastic mulches can be used to establish crops in the summer, when a reduced soil temperature is beneficial. As light is reflected discomforting the sucking insect pests in the lower side of canopy thus reducing the sucking insect pest pressure and build-up.

SEEDLING HANDLING AND TRANSPLANTING

05

How to Select Healthy Seedlings

Observe the hygiene of the nursery: It is always important to obtain seedlings from a clean and well-maintained nursery. Even if the seedlings appear healthy, they can still harbour viruses if the surroundings are not clean. Check for fine-meshed and undamaged insect netting on the side walls, properly closed double doors, weed-free surroundings, the installation of sticky traps inside the nursery and no water stagnation under the seedling trays in the nursery.

Read the label on the trays: Check for the variety and the date of sowing on the label.

Avoid the biggest and tallest: Never believe that the biggest and tallest seedlings will establish faster in the field. They may have weak stems and take a long time to establish.

Look at the roots: A poor root system will produce a weak plant. Pick the seedlings that have a strongly developed root system to help them perform better in the field.

Avoid over-aged seedlings: It is recommended to transplant 25 - 30 days old seedlings. Older transplants may produce earlier yields but may bring more pest and disease problems.

Check the foliage: Pale and yellow foliage might indicate a nitrogen deficiency. Look for a uniform colour on all the leaves- whether dark or light green. Avoid very pale and dark green seedlings.

Avoid seedlings with their roots protruding out of the cavities: When such seedlings come into contact with the soil, they are more likely to carry soil-borne pathogens.

Inspect the seedlings for any insect pests or diseases: Make sure that the leaves are not carrying any eggs and larvae of insect pests or any diseased spots.

Check for the moisture in the cocopeat: If there is excess moisture in the growing medium, it may hinder the uptake of nutrients due to the build-up of salts or attract fungal spores as soon as the seedling is transplanted.

NUTRIENT MANAGEMENT

06

Plants need many different nutrients. Macronutrients are the nutrients that plants need in high quantities while secondary and micronutrients are required in moderate and small quantities, respectively.

Nutrients	Role	Deficiency symptoms
Primary nutrients		
Nitrogen (N)	Component of amino acids, protein and chlorophyll. Important for biomass formation.	Stunted growth, slow growth, and chlorosis
Phosphorus (P)	Component of many hormones and biomolecules. Important for plant growth and seed formation.	Intensive green, sometimes purple colour of leaves, necrosis in older leaves
Potassium (K)	Metabolic nutrient. Improves plant growth, fitness and stress tolerance.	Chlorosis, brown spotting, pathogens, wilting
Secondary nutrients		
Calcium (Ca)	Regulates the transport of other nutrients into the plant and is also involved in the activation of certain plant enzymes. Involved in photosynthesis and plant structure.	Stunting, growth disorders, backend Rot fruit
Sulphur (S)	Sulphur is a structural component of some amino acids and vitamins and is essential in the manufacturing of chloroplasts. It is immobile and deficient therefore it affects younger tissues first.	Yellowing of leaves and stunted growth.
Magnesium (Mg)	Constituent of the chlorophyll molecule. Promoter of enzyme reactions. Magnesium is very mobile in plants, and, like potassium, when deficient, is translocated from older to younger tissues, so that signs of deficiency appear first on the oldest leaves and then spread progressively to younger tissues and is also a very important part of our body too.	Chlorosis in between the veins almost similar to nitrogen deficiency which turns to scorching in severe conditions.

Nutrients	Role	Deficiency symptoms
Micronutrients		
Iron (Fe)	Necessary for photosynthesis.	Decoloured or dead patches between the leaf veins.
Molybdenum (Mb)	Required for building amino acid	
Boron (B)	Cell wall stability, uptake of nutrients.	Stunted growth, deformation.
Copper (Cu)	Important for photosynthesis.	Decoloured leaves.
Manganese (Mg)	Photosynthesis and building of chloroplasts.	Discoloured spots on the foliage.
Zinc (Zn)	Important for enzymes.	Stunted growth of leaves.

Good Nutrient Management Practices

Soil fertility depends on many factors, such as its organic matter content, cation exchange capacity (CEC), pH value and salinity (determined by its electrical conductivity (EC). For the grower, the important questions related to soil fertility management comprise the stock of nutrients in the soil and their availability to the plants.

Following are the recommended practices for good nutrient management in tomato cultivation:

- Apply nutrients based on expected yield.
- Generally, Tomato requires nutrients in the ratio of 5N:1P_2O_5:7K_2O:2CaO.
- Use N:P_2O_5:K_2O:CaO in ratio 1:1:2:0.5 (this is taking into consideration availability in the soil after application)
- Use more Calcium in sandy soils with lower pH
- Use micronutrients (Zn, Mg, B)
- Apply N:P:K – 30%:30%:20% of total requirement as basal dose
- Apply starter dose in planting hole: N:P:K at 4%:15%:3% of total requirement
- weekly application of fertilizer N:P:K:Ca:Mg at 9%:8%:11%:15%:15% of total requirement from day 21 onwards.
- Never apply Boron to soil but apply foliar spray after heavy rains and from flowering onwards.

(Note: These are general requirements. However, based on the soil test analysis only the required quantities should be applied. Cost and produce price also need to keep in mind for maximisation of the profits)

Use of Micronutrients and Growth Regulators

- **Micronutrient spray:**
  - Foliar spray of $ZnSO_4$ at the rate of 0.5 per cent thrice at 10 days intervals from 40 days after planting.
  - Spray 19:19:19 + Mn at the rate of 1% at 60 days after planting.
- **Growth regulators:**
  - Spray 1.25 ppm (1.25 ml/l or 125 ml in 100 litre of water) Triacontanol at 15 days after transplanting and at full bloom stage to increase the yield.

Use of Organic Manure

The use of organic manure is particularly important, as it does not only supply a variety of nutrients, especially phosphorus and micronutrients, but it also adds organic matter to the soil, which improves the general soil fertility and physical properties.

The richest organic manure is farmyard manure (FYM). FYM refers to the decomposed mixture of dung and urine of farm animals along with litter and leftover material from roughages or fodder fed to cattle. It contains substantial amounts of all macro elements (N, P, K) and traces of many micronutrients. For hygienic reasons and for good nutrient availability it must be well composted.

Organic manure can also be applied in the form of compost or vermi-compost from composting plant residues. There are different ways of producing compost for the use in tomato production.

It is important to ensure that the composting process has taken place completely, destroying all pathogens and avoiding carry-over effects. This is especially important if the compost contains plant material from tomato, chilli or brinjal plants.

Amendments to improve the soil sanitary status

Neem cake is the residual product from neem-oil production, a bio-pesticide. Apart from its nutritional benefits, neem cake contains residues of neem oil, which kills insect eggs and pest insects that seek cover in the soil. *Trichoderma harzianum, Trichoderma viridae* are fungi, which are not harmful to the crop but compete with fungal pathogens, preventing fungal diseases. Being a fungus itself *Trichoderma* is susceptible to fungicides.

The underlying functions are not yet completely understood, but it has been shown that *Pseudomonas fluorescens* is effective against some *Fusarium spp.* and reduces the nematode population. *Paecilomyces lilacinus, Pochonia chlamydosporia* are fungi, which parasitize and kill eggs, juveniles and young adults of phytophagous nematodes. *Metarhizium anisopliae* being a broad spectrum entomopathogen known and being used to wardoff many plant pest insects. Now a days it is being explored in depth for its potential in increasing plant immunity towards many pests and diseases too.

Amendments to Improve the Nutrient Availability of the Soil

Azotobacter spp., Azospirillum spp. are free-living, nitrogen-fixing bacteria. They can fix nitrogen from the air and make it available for plant nutrition. Air consists of 78% nitrogen, one of the most important plant nutrients but its chemical form (N2) makes it inert, so that plants cannot use it. Rhizobium bacteria that live in symbiosis with legume plants, are well-known for taking N from the air and making it available to the host plant. Phosphate Solubilizing Bacteria (PSB) are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds. Thereby, these bacteria improve the P availability for the crop (e.g. *Pseudomonas fluorescens, Bacillus subtilis*). These microbial cultures are available in talc powder form with different trade names from local fertilizer and pesticide shops.

Basal FYM Enriched with Microbial Agents

One tonne of well decomposed FYM is thoroughly mixed with one or more of the following amendments: *Azotobacter* or *Azospirillum*, Phosphate Solubilizing Bacteria (*Pseudomonas fluorescens* or *Bacillus subtilis*), *Trichoderma harzianum* or *Trichoderma viridae*, *Paecilomyces lilacinus* or *Pochonia chlamydosporia* and *Metarhizium anisopliae* at the rate of 1 kg each. Which and how many of the amendments are used in the mixture depends on other aspects of farm management, as well as on the availability and cost of the respective amendment. The mixture is moistened by sprinkling water and covered with wet gunny cloth and kept incubating for about 3-4 weeks (20-28 days) under partial shade. For better aeration and decomposition, turn the FYM after about 10-12 days. This one tonne of enriched FYM should be mixed with nine tons of straight FYM to make it to ten tons of FYM mixture for broadcasting on one hectare in the main field

Basal Neem Cake Enriched with Bio-fertilizers and Bio-pesticide

Powdered neem cake (100 kg) with an oil content of 10-12 % is thoroughly mixed with *Azotobacter* or *Azospirillum*, Phosphate Solubilizing Bacteria (*Pseudomonas fluorescens* or *Bacillus subtilis*), *Trichoderma harzianum* or *Trichoderma viridae*, *Paecilomyces lilacinus* or *Pochonia chlamydosporia* and *Metarhizium anisopliae* at the rate of 1 kg each. This is then moistened by sprinkling water and covered with wet gunny cloth before allowing it to incubate for about 10-12 days under partial shade. If it is to be stored for a few more days, it is advised to give it a turn for better aeration and decomposition. This enriched neem cake can be applied to the main field along with 10 tons of straight FYM at the time of bed preparation for planting.

CANOPY MANAGEMENT AND STAKING

07

Staking tomatoes improves fruit quality by keeping plants and fruits off the ground and by providing better spray coverage.

It is also easier to harvest staked tomatoes than tomatoes growing across the ground. Vigorous cultivars may require larger and longer stakes. Stakes can be driven a foot deep into the soil with the help of a crowbar.

In general, growing plants have to be staked as soon as the branches start developing around 25-30 days after transplanting. This may vary slightly with the growth habit of the variety.

Improved Method of Staking

The strong wood or bamboo poles are over 7 ft (210 cm) long and fixed on both sides of the plant rows and brought together to be tied into an inverted V shape. A strong thread or metal wire is run across the joined portion, and each individual plant is tied to this with the help of jute or nylon thread. This provides strong support to the plants helping them withstand heavy winds. Depending on the kind of wood used, the poles are disposed after use. While bamboo poles generally only stand one season, other types of wood may be more resistant.

- Stake the plants 25-30 days after planting with 1.5-2.0 meter tall stakes.
- Fix bamboo poles in between the rows in the ridges at a pole-to-pole distance of about 10 ft (3 m).
- Run metal wires or strings across horizontally at a uniform height connecting all the poles.
- Tie each plant up vertically with the help of a thread to these horizontal strings.
- This provides a very good support system for determinate types of tomatoes.

Removal of Lower and Older Leaves

Removal of lower leaves (bottom 6 inches when the plant is 18 inches high) to reduce the initiation and spread of diseases from the soil-surviving pathogens.

Pruning

Pruning helps maintain a balance between vegetative and reproductive growth. If you do not prune or prune very little, your tomato plants will produce excessive vegetative growth with reduced fruit size. Moderate pruning will leave your plants with smaller vines and larger fruit that will mature earlier. Pruning keeps plants and fruit off the ground, helping to control diseases. Although pruning requires a lot of effort, the benefits of doing so are more marketable fruit, easier harvesting, and reduced injury to plants when multiple harvests are being made. This practice is most profitable when a long harvest season is possible and when there is uniform fruit production over the season.

The most common method is pruning to produce a two-stemmed plant by pinching off lateral branches, known as suckers, as they appear in the axils of each leaf. If it is practically difficult, it may be recommended to prune up to four to five stems.

A single pruning will usually be adequate, although a later pruning may be needed to remove suckers growing from the ground at the base of the plant. Suckers should be removed when small, no more than 2-4 inches in length. Pruning should be done in the early morning or on a dry day when leaves are just visible with a very small wound. This will allow good healing and a low risk of infections.

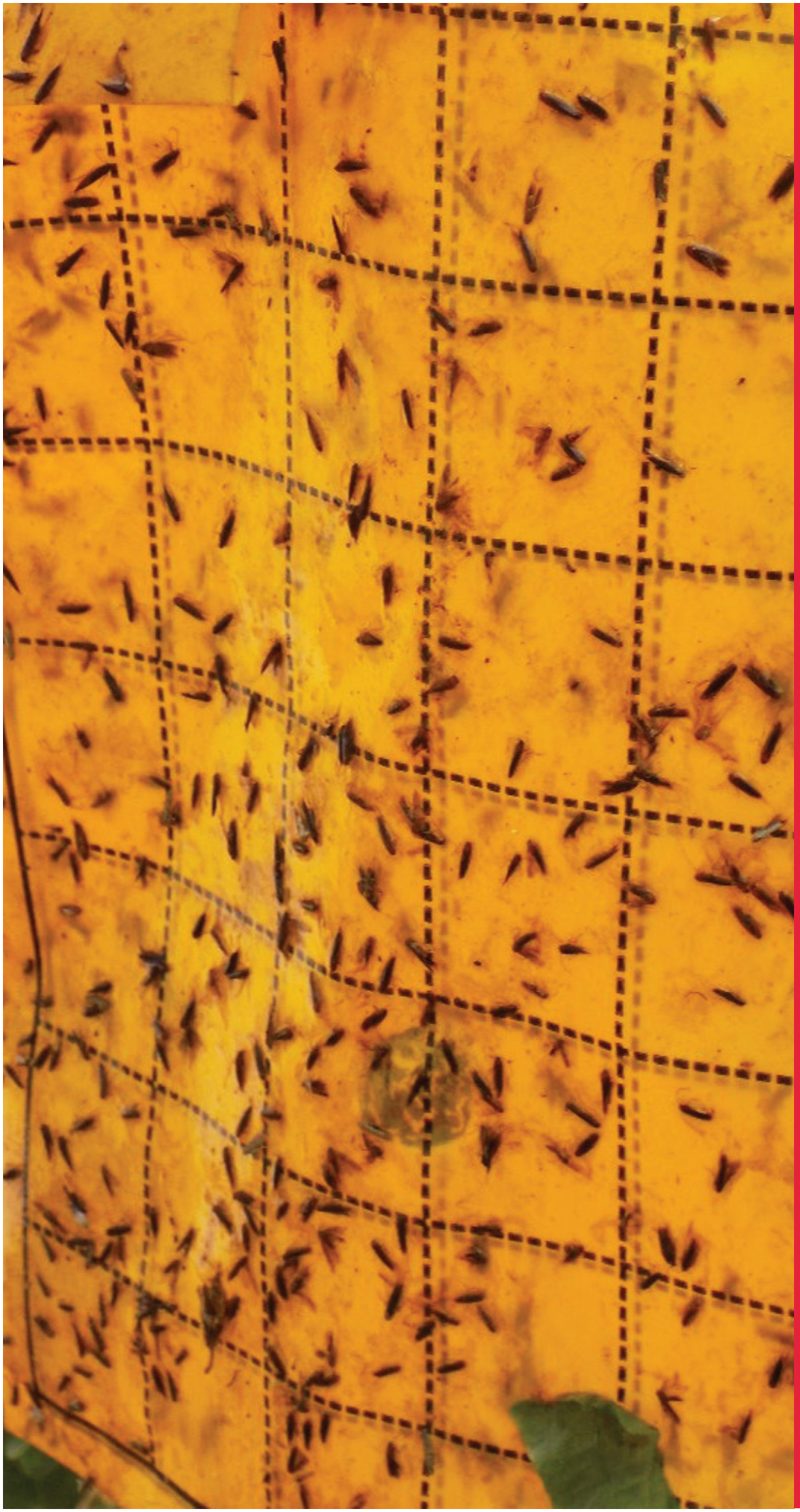
WEED MANAGEMENT

08

Weed control before planting is best done mechanically. Therefore, the field is not worked for about two weeks in order to allow weeds to germinate.

After that, the field is ploughed with a mouldboard plough or a disc plough, which mechanically destroys the germinated weeds and incorporates them into the soil.

Afterwards, a light harrow is used for producing a fine crumble structure, before the actual ridges are made. On small fields, the use of a power tiller is recommended for mechanical weed control and seedbed preparation.



PEST MANAGEMENT

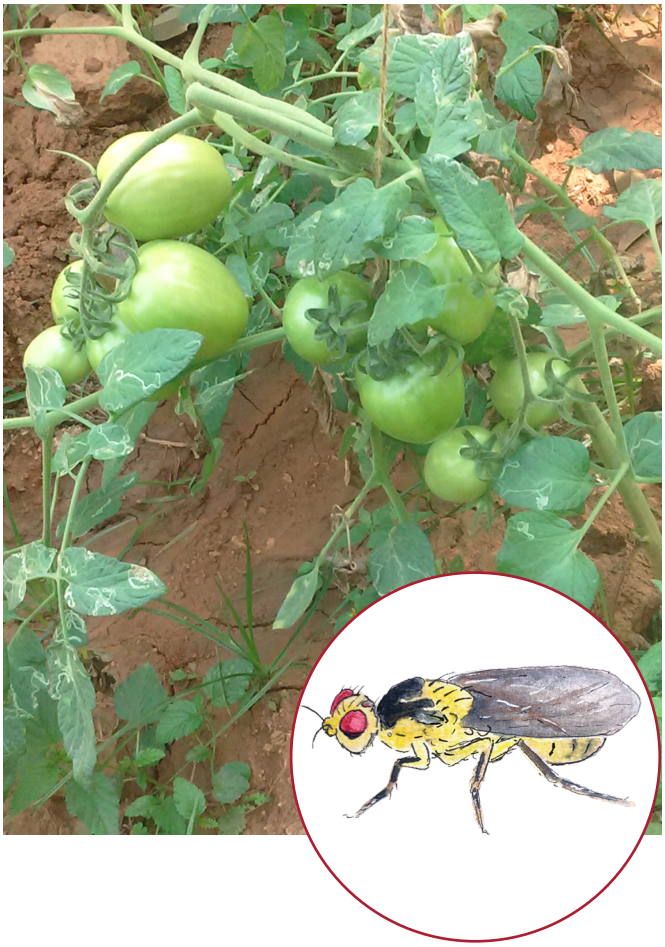
09

9.1 American Serpentine Leaf Miner

Liriomyza trifolii (Burgess) (Diptera: Agromyzidae)

Symptoms

- Leaves with serpentine mines
- Mining symptom on leaf
- Drying and dropping of leaves



Management Practices:

- Pinching the damaged leaves at transplanting.
- Planting the castor around the border for trapping and destruction of infested foliage as soon as infestation/damage in noticed.
- Use of mulch will reduce the pupation and pest build-up
- Collection and destruction of mined leaves.
- Yellow stick traps will lure the adults and very effective and eco-friendly.
- Spray NSKE 4% or 0.5 ml spinosad 2.5 EC (Spynosyns) or 0.6 ml Abamectin 1.9 EC (Avermectin)
- Spraying during early morning hours is more effective.
- Encourage natural enemies – Diglyphus begini and Opius dissitus

9.2 South American Tomato Leafminer

Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae)

Symptoms

On foliage

- Larvae feed mesophyll content making transparent layers on the surface of leaves.
- Larvae feeds on young shoots, leaves and young stem
- Under saviour pest incidence, crop looks dried

On Fruits

- Damage initiates during fruit formation/marble sized
- Small pin sized holes with or without frass
- Larvae bore holes, feeds on mesocarp tissues
- Feeding holes act as entry point for Secondary infection by pathogens

Larvae Life Stages

- 1st instar: feeds near to the oviposition site
- 2nd instar: “wandering stage” - Move to lower leaves hanging through silken threads
- 3rd instar: feeds and make large blotches/pinholes on fruits
- 4th instar: Wanders over plant/fall on the soil for pupation
- Total larval duration: 8 days

Favourable Conditions

- Optimum temperature for Tuta absoluta population growth 20-23 °C
- Host plants for Tuta absoluta are: potato, tobacco, capsicum, amaranthus

In recent years Tuta absoluta is a most devastating infestation for tomato. In the absence of control measure it can cause 80-100 % yield losses.

Management Practices

- Erection of Pheromone trap and light trap with water pan outside the nursery to trap and kill adults and at and 4 ft above crop height in the main field (10-20/acre) and 1-4/acre, respectively).

Under open field conditions erection of pheromone traps all around crop boundary or 10-15 ft away from the crop boundary is more advantageous in reducing pest damage.

- Pinching the damaged leaves before transplanting.
- Seedling root treatment with 0.3 g Thiamethoxam before transplanting.
- Application of 250 kg/acre neem cake at transplanting and 30 DAP in two splits.
- Use of plastic mulch will reduce the pupation and pest build-up.
- Collection and destruction of mined leaves.
- Spray NSKE 4%, 1 ml Bt (Dipel), 5 g Metarhizum anisopliae, 5 g Beauveria bassiana, 0.3 ml cyantraniliprole, 0.15 ml chlorantranilipole (Diamides), or 0.5 ml indoxacarb (Na channel blocker) at 15 days interval
- Spraying during early morning hours is more effective.
- Crop residue destruction after cropping period and avoid monocropping.
- Encourage natural enemies – Neochrysocharis formosa and Nesidiocoris tenuis.

Cropping systems for management of *Tuta absoluta*

Crop Rotation :

- Tomato should not be grown successively on the same field.
- Break of at least 3 months is required between planting of tomatoes or other Solanacesous crops (e.g. chillies, brinjals, capsicum, potato, tobacco, etc.)
- The crops that can be grown after tomatoes, are cereals (maize, sorghum, wheat, millets, etc.), cruciferous crops (cabbage, cauliflower, etc.) or radish, watermelon, onion, garlic, groundnut, cotton, safflower, sunflower, sesame, sugar beet and marigold

9.3 Tomato Fruit Borer

Helicoverpa armigera (Hubner)
(Lepidoptera: Noctuidae)

Symptoms

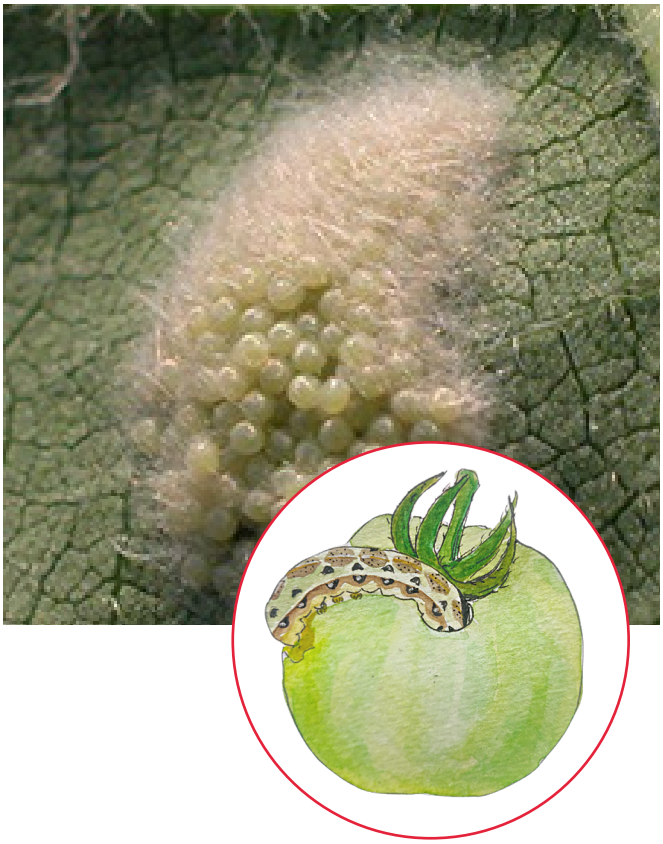
- Young larvae feed on tender foliage
- Mature larvae bore circular holes
- Thrust only a part of its body into fruit and eat the inner content

Management Practices

- Planting 45 days old Marigold plants around and after every 15 rows of tomatoes and harvesting flowers weekly twice.
- Planting the sunflower/castor around the border for monitoring *Spodoptera litura* and collection and destruction of egg masses/gregarious young larvae.
- Random sowing of radish and coriander to repel fruit borer moths and to attract parasitoids.
- Erection of pheromone trap and light trap with sleeve/ pan traps 1 foot above crop height (10 per acre).
- Weekly use of *Trichocards* at a rate of 4 cards/acre/ week starting from 40 DAP.
- Spray NSKE 4% or 1 ml Bt (Dipel) or 5 g *Metarhizum anisopliae* or Beauveria bassiana or *Metarhizum* (*Nomuraea*) *releyie* or EPN (1 - 2 kg/acre) or 2 ml profenophos (OP) or 0.15 ml *chlorantriniprole* (Diamides) or 0.5 ml indoxacarb (Na channel blocker) based on pheromone trap catches if there are more than 10 moths/night continuously for 4 days. (Do not repeat same insecticide for a second spray continuously)

9.4 Tobacco caterpillar

Spodoptera litura (Fabricius)
(Lepidoptera: Noctuidae)



Management Practices

- Plough the soil to expose and kill the pupae
- Grow castor along border and irrigation channel as trap crop
- Flood the field to drive out the hibernating larvae
- Set up 1 light trap per hectare
- About 15 Pheromone traps (Pherodin SL) per hectare to attract male moths
- Collect and destroy egg masses in castor and tomato
- Hand pick grown up larvae and kill them
- Spray Sl NPV at the rate of 1.5 x 1012 POBs/ha + 2.5 kg crude sugar + 0.1% teepol
- Apply poison bite: Rice bran 5 kg + Molasses or Brown sugar 500 g + Carbaryl 50 WP 500 g + 3 l of water per hectare. Mix the ingredients well and keep it around the field in the evening hours.

9.5 Whitefly

Bemisia tabaci (Gennadius), (Hemiptera:Aleyrodidae)

Symptoms

- Feed on leaf undersides removing plant sap causing plant weakness
- Under severe conditions, numerous chlorotic spots which grow together forming different sized yellow areas leaving only veins green.
- Some leaves appear completely brown and dried, wilting and leaf drop may occur.
- A sticky, black sooty mould development on leaves, stems and fruits.
- Active adults transmit the begomovirus, Tomato yellow leaf curl.
- Active feeding adults acquires virus from phloem of virus infected plants. They need at least 15 minutes to acquire the virus and 15 to 30 minutes to transmit it to another healthy host plant.

9.6 Thrips: Western Flower Thrips

Frankliniella occidentalis (Pergande), Tomato Thrips, Frankliniella schultzei (Trybom), Onion Thrips, Thrips tabaci Lindeman (Thysanoptera: Thripidae)

Symptoms

- Adult and larval thrips damage flowers, fruits and leaves.
- On leaves and flowers: silvering, streaking, bronzing or distortion of leaves, petals and sepals.
- On immature fruit: small scars that elongate with fruit growth.
- On mature fruit: silvering or russeting (brownish roughened area on the skin of fruit).

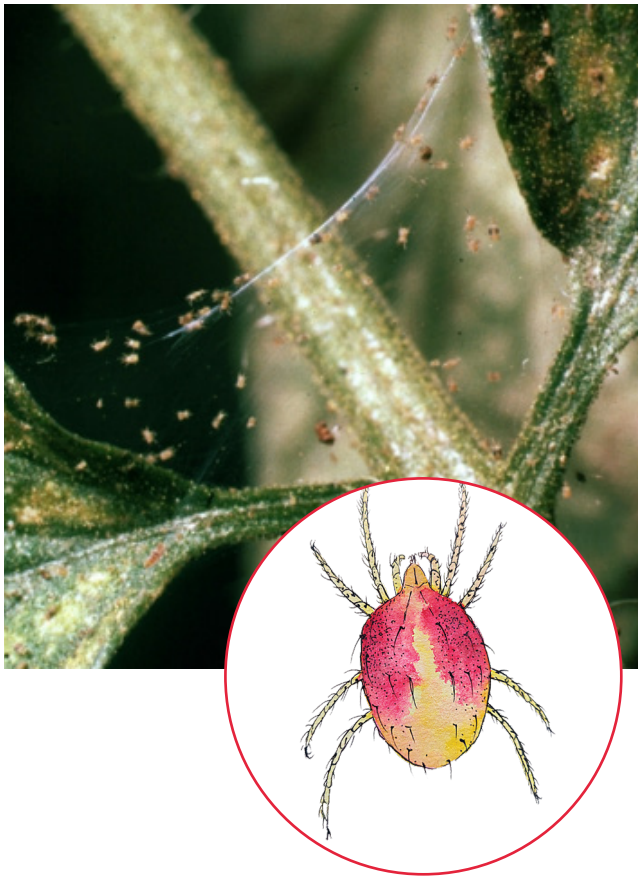
Sucking Pests (whitefly and thrips) Management

- Application of 250 kg/acre neem cake at 0 and 30 DAP.
- Sowing one or two thick rows of maize/sorghum around the border and in between every 15-20 rows to prevent easy spread of whiteflies and thrips from outside and within the field.
- Scattered planting of coriander to encourage natural enemy activities.
- Seedling root treatment before transplanting or drenching the portrays a day before transplanting with 0.3 g thiomethoxam.
- Install yellow and blue sticky traps to lure and kill adults at the rate of 40-80/acre (20-40 each) depending on season and pest load.
- Use sprinkler irrigation to reduce the temperature and pest under dry spells and summer.
- Spray 5 ml Neem oil with 0.5 ml shampoo or NSKE 4% or 5 g *Metarhizum anisopliae* or *Lecanicillium leccani* or *Hirsutella thompsoni* or 5.0 ml Lastraw® (petroleum oil formulation) in the early stages of pest notice.

- Synthetic chemicals like 0.3 ml spinosad 45 SC or 1.0 ml spinetoram 11.7 EC (spinosins) or 0.25 g acitamiprid 20 SP or 1 g diafenthiuron 50 WP (organotine) or 0.3 ml cyantraniliprole (Diamides) or 1 g acephate 75
- SP (OP) based on pest load at a 10-15 days interval. (Do not repeat same insecticide for a second spray continuously)

9.7 Red Spider Mite

Tetranychus urticae Koch (Arachnida: Acari: Trombidiformes: Tetranychidae



Symptoms

- Sucking sap or feeding makes the leaves yellowish white and mostly mottled. Affected leaves become reddish brown and bronzy.
- In severe conditions severe web spinning, first in the ventral leaf surface, later full leaves sometimes the whole plants will be densely webbed leading to withering and drying of leaves and plants.
- Flower and fruit formation will be severely affected

Red Spider Mite Management

- Upon dry spell incidence, start with spray with 1.0 ml Azadirachtin 10000 ppm, IIHR Neem Soap 1%, Neem Oil 1%, synthetic acaricides like 0.6-1.0 ml Abamectin 1.9 EC (Avermectin), 1.5 ml Ethion 50 EC, 3 g wettable sulphur 80 WP, 1.5-2.0 ml Propargite 57 EC, o 2.0 ml Fenazaquin 10 EC
- Spray lower Surface of the leaves.

Principles of Integrated Pest Management

- Variety/Hybrid resistant/tolerant to major pests
- Select healthy seeds/seedlings/planting material
- Treat the seeds/seedlings/planting material with recommended pesticides/ biopesticides
- Proper spacing
- Soil health improvement (organic matter, green manuring, mulching, etc.)
- Nutrient management (organic manures and biofertilizers; soil test results).
- Balanced dose of fertilizers to avoid susceptibility to insects and diseases and retarded crop growth.
- Proper irrigation
- Crop rotation

IPM Package for Tomato

- Produce healthy seedlings (use seedling trays, sterile rooting media – if possible, treat it with Trichoderma, and under net-house/net-tunnels; use grafted seedlings, if bacterial wilt is a major threat; choose a variety/hybrid, which is resistant to TYLCV disease).
- Monitor the pest and natural activity and abundance regularly on field/crop and in sticky and pheromone traps. Change the sticky traps and lures as prescribed.
- Install yellow and blue sticky traps at 40-100 traps/ha soon after transplanting.
- Install Tuta absoluta pheromone traps at the rate of one in 250-300 m_2 at 2.0-2.5 ft from ground (within crop canopy) within the crop or along the crop boundary as explained earlier soon after transplanting. Install Spodoptera litura (if it is a problem) pheromone traps at one in 400 m_2 soon after transplanting. Install Helicoverpa armigera pheromone traps a one in 400 m_2 at the time of flower initiation. Install Spodoptera and Helicoverpa traps at 30 cm above canopy level. Use funnel traps (e.g., Fero-T® from PCI) for S. litura or H. armigera and water traps for Tuta absoluta. (e.g., Wota-T® from PCI and Tutasan®) from Koppert.
- Spray neem oil formulation or Lastraw®, if sucking pests (especially whitefly) appear to cause damage (first spraying); if both sucking pests and Tuta absoluta appears, then spray Econeem Plus® or Neemazol®- Azadirachtin 10,000 ppm (1%) EC, or Ecotin®- Azadirachtin 50,000 ppm (5%) EC (instead of Lastraw) (first spraying).
- Spray Spodoptera litura nuclear polyhedrosis virus (SlNPV) or Helicoverpa armigera nuclear polyhedrosis virus (HaNPV), if S. litura or H. armigera damage alone is noticed; if they occur along with Tuta absoluta or Tuta absoluta occurs alone, then spray Bacillus turingiensis var. kurstaki, (Delfin® or Green Larvicide®) (second spraying).
- Spray Beauveria bassiana formulation (BB Power® or Green Beauveria®) or many formulation available with farm university KVKs and Colleges as well as local market) at the recommended dose if S. litura, H. armigera and/or Tuta absoluta damage continues to persist along with cool and humid weather (third spraying).
- Spray Chlorantraniliprole (Coragen®) or emamectin benzoate at recommended dose for caterpillar pests (fourth spraying).
- Spray Spinosad or Spinetoram at recommended dose for caterpillar pests for the fifth spraying.
- Maintain 10-15 days interval between two successive spraying, especially after second spray. Keep monitoring for the reduction in pest number or damage

Regular Field Observation (Climate,Soil and Biotic Factors)

- Monitor the field situations at least once a week (soil, water, plants, pests, natural enemies, weather factors, etc.)
- Make decisions based on the field situation and Pest: Defender ratio (P:D ratio 2:1)
- Take direct action when needed (e.g. collect egg masses, remove infested plants, etc. as detailed in earlier sections)
- Inundative release of parasitoids/predators or usage of microbial biopesticides, insect growth regulators, botanicals, etc. depending upon the type and stage of insect pest.
- Synthetic chemical pesticides should be the last option and usage of the same synthetic chemical insecticide molecule for second consecutive spray should be avoided.

DISEASE MANAGEMENT

10

10.1 Diseases of rainy season

10.1.1 Late Blight

Symptoms

- Necrotic brown lesion appears on the upper surfaces of the leaves
- On the outer margin of the necrotic lesion, white sporulation appears on the lower surface leaves when the humidity is higher
- Necrotic lesion on stems and rotting from stalk end of fruits, followed by white sporulation when humidity is more
- Under severity leaves appear burnt

Favourable Conditions

- Continuous rainfall or heavy dew for 2 or more days followed by cloudy weather
- If irrigation provided more than the requirement
- If lower leaves are touching the soil/ground
- If the spacing provided for planting is less or staking is improper/not followed
- Supply of more than the recommended dose of nitrogenous fertilizer

Management Practices

- Planting at optimum spacing for better aeration
- Staking plant using pole and wire for proper growth and better aeration
- Collect and destroy the infected leaves, fruits and plant parts
- Avoid providing excess irrigation and irrigation during night-time
- Provide optimum dose of farmyard manure, potash and micronutrients
- Avoid excess use of nitrogen fertilizer
- Spray of fungicides

Preventive Sprays

- Mancozeb: 2 g/l
- Propineb: 2 g/l
- Chlorothalonil: 2 g/l
- Mandipropamide: 1 ml/l

Immediately After Infection

- Mancozeb + Cymoxanil: 2 g/l
- Iprovalicarb + Propineb: 3 g/l

Severe Infection

- Dimethomorph: 1 g/l and Mancozeb 2 g/l (as tank mix)
- Dimethomorph + Ametoctradin: 2 g/l
- Fosetyl Al + Fluopicolide: 2.25 g/l

10.1.2 Early Blight

Symptoms

- Initially there will be small spots on the leaves near the surface of the ground
- Later small spots coalesce to form blights with a concentric ring of fungus sporulation
- Under severe conditions stem and fruits infection was observed with concentric ring spots/blights
- Severely infected leaves of the plant from a distance appear pale and burnt

Favourable Conditions

- Continuous rainfall or heavy dew for 1 or 2 days followed by bright sunny days
- If irrigation provided more than the requirement
- If lower leaves are touching the soil/ground
- If the spacing provided for planting is less
- Supply of more than the recommended dose of nitrogenous fertilizer

Management Practices

- Planting at optimum spacing for better aeration
- Avoid leaves contact with soil
- Staking plant using pole and wire for proper growth and better aeration
- Collect and destroy the infected leaves, fruits and plant parts
- Avoid providing excess irrigation and irrigation during night-time
- Avoid crop rotation or continuous cropping with other hosts of a pathogen like chilli, capsicum, or potato on the same land
- Provide optimum dose of farmyard manure, potash, and micronutrients
- Avoid excess use of nitrogen fertilizer
- Spray of fungicides
- Mancozeb: 2 g/l
- Propineb: 2 g/l
- Chlorothalonil: 2 g/l
- Difenoconozole: 0.75 ml/l
- Captan+Hexaconazole: 2 g/l
- Zineb+Hexaconazole: 2 g/l
- Thiophonate methyl: 1 g/l
- Azoxystrobin:1 ml/l

10.1.3 Powdery Mildew

Symptoms

- Growth of white powdery growth on the upper surface of leaves
- Sometimes chlorosis appears on the upper surface of leaves and growth of white powdery growth on the corresponding lower surface of leaves
- Under severe infection inward folding of leaves with yellowing and later leaves fall off

Favourable Conditions

- Cool nights, and sunny days coupled with high relative humidity weather for more than 2-3 days
- If the spacing provided for planting is less
- Supply of less than the recommended dose of potassium fertilizer

Management Practices

- Planting at optimum spacing for better aeration
- Application of optimum doses of potassium fertilizers
- Spray of fungicides
  - Potassium bicarbonate: 10 g/l
  - Myclobutanil: 0.4 g/l
  - Hexaconazole: 1 m/l
  - Difenoconozole: 0.75 m/l
  - Tebuconazole: 0.50 m/l

10.2 Diseases of Summer Season

10.2.1 Leaf Curl Virus

- It spreads from white flies
- Leaf curl disease is characterised by severe stunting of the plants with downward rolling and crinkling of the leaves.
- The nodes and internodes are significantly reduced in size.
- The infected plants look pale and produce more lateral branches giving a bushy appearance.
- The infected plants remain stunted.

Management practices

- Install yellow sticky traps 20-25 traps/hectare to control whitefly.
- If the incidence is high, spray Dimethoate 30% EC @ 1 ml/L or neem seed kernel extract 4% (NSKE) or neem oil @ 8-10 ml/L or neem soap @ 10 g/L.
- The best long-term controls are to use resistant varieties and to buy seedlings from a nursery that fully protects seedlings from early whitefly infestations.

10.3 Other disorders

There are a number of disorders caused by adverse environmental conditions during growth and development, storage and marketing. Fruit cracking, blotchy ripening, puffiness, sunscald and blossom end rot are important ones.

10.3.1 Cracking of Tomato

Cracking of tomatoes is very common. Four types of cracking, radial, concentric, burst and cuticular, are found. Concentric and radial are very severe and are mainly because of soil moisture, rain, dew and plant vigour. When rain follows, a long dry spell there is cracking. High-day temperatures followed by low temperatures with high relative humidity also cause fruit cracking. In calcareous soil, deficiency of B causes cracking.

Management Practices

Soil application of borax at a rate of 15-20 kg/ha or spraying of borax (0.25%), 2-3 times at the fruiting stage to ripening reduces fruit cracking. There should be proper control of moisture, especially at fruit maturity and ripening stages. Thick foliage and pericarp of fruits are associated with less cracking.

10.3.2 Blossom End Rot

Blossom-end rot is a severe physiological disorder. It is caused by a calcium deficiency. . To control this disorder, calcium sulphate, calcium hydroxide and calcium chloride should be applied.

10.3.3 Puffiness

In puffiness, the fruit surface is generally flattened and locules are unfilled with pulp and seed. The affected fruits become light in weight and more or less hollow. The outer wall (pericarp) shows normal growth but the remaining internal tissue especially parenchymatous tissue is retarded in growth, resulting in lightweight and partially filled tomatoes. Puffiness is associated with poor pollination, and abortion of ovules due to

adverse environmental conditions particularly high and low temperatures.To reduce its incidence, maintenance of normal temperature, frequent irrigation, spraying of boric acid (10–15 ppm) and some growth regulators are required.

10.3.4 Greenish / Yellow Patches

Greenish-yellow to whitish patch on tomatoes, mostly on the stem-end portion of the fruits, is called blotchy ripening. Caused mainly by K deficiency, it occurs due to an imbalance of N and K. High levels of N, Ca and Na are associated with blotchy ripening.

To control blotchy ripening, potassic fertilizer should be applied adequately and temperature should be controlled. Short photoperiod and relatively low day temperature reduce its incidence.

10.3.5 Sunscald

Sunscald and low-temperature injury are general problems for tomatoes in summer and winter. On exposure of tomatoes to high temperatures (40°C and above) and high sunlight, whitish, greyish, sunken and papery lesions develop. These lesions may have a secondary infection of fungus which shows black dark spots, making tomatoes unfit for consumption. Varieties having sparse foliage, thin pericarp and immature size are more prone to this. At low temperatures also, tomatoes are frosted and injured showing whitish-yellow, sunken symptoms. Dense foliage varieties with thick pericarps developed in temperate countries are less prone to low-temperature injuries.


BASF

SPRAYING TECHNIQUES

11

Spraying techniques matter most for judicious use of chemicals and their effectiveness.

However, farmers largely neglect this aspect and use the sprayers whatever is available in the market.

Hence, the problems are:

- Indiscriminate use of pesticides
- Usage of defective nozzles which have high discharge, leading to dripping of chemicals from leaves
- Non-uniform spray pattern due to too swinging of lance
- Less use of personal protection equipment
- Less knowledge about Pre-harvest intervals
- of pesticides
- Farmers need to be educated on the right selection of nozzles and lancers

11.1 Nozzles

Nozzles have effects on:

- Amount of chemicals applied
- Uniformity of spray
- Coverage of chemicals on the surface
- Drift

Nozzle Selection and Spray Quality

Flat fan nozzles: Standard and even spray types. These standard types can be used on small multi-nozzle booms whilst even spray designs produce uniform deposits from a single nozzle

The flat fan nozzle has a lens-shaped or elliptical orifice. This produces a narrow lens-shaped pattern, with the highest spray deposit occurring immediately under the nozzle and the amounts of spray lessening towards the edges of the fan. This means the swaths must be overlapped to achieve an even deposit on the target, and hence are usually used in an overlapping fashion on a spray boom.

These nozzles are produced in a range of sizes and possible spray angles although the most used spray angles are either 80° or 110°. The larger spray angle (110°) gives a wider swath but generally produces smaller droplets.

Fan nozzles are most suitable for spraying flat surfaces such as soil when applying pre-emergence herbicides, to walls of buildings, for example, when spraying against insect disease vectors or stored product pests.

A special type of flat fan nozzle is known as the 'even spray' nozzle. This is designed to give an even deposit across the swath to eliminate the need for overlapping swaths and is best suited for a single nozzle on a knapsack lance when band or strip spraying. They are most commonly available only with an 80° spray angle.

Most flat fans are designed to produce a specified throughput and spray angle at a spray pressure of 40 psi or 3 bar. However, also available are low-pressure (LP) flat fan nozzles, which give the same flow rates and spray angles but at 15 psi (1 bar). These tend to produce larger droplets and so are better for herbicide spraying to minimise drift.

Checking Application quality: Using water-sensitive papers to ensure optimal coverage

Application quality: Check spray coverage on target vegetation

Spray with water only. If the leaves are soaked and water drips from the leaves then the application volume is too high.

Using water-sensitive paper

Use paper clips or staplers, and fix water-sensitive papers on the crop canopy, particularly in target areas where you need to get good spray coverage. Spray the area following your normal spray practice with clean water. Collect up the papers and look at the droplet coverage.

11.2 Low-cost Boom Sprayer for Effective Spraying

The Green Innovation Centre project has developed a low-cost boom sprayer for effective spraying. The boom will come with eight nozzles and can be fitted to the knapsack sprayer.

The benefits of using such boom sprayers are:

- Reduces spraying time drastically (max 1 hour/ac) which is crucial in the rainy season
- Good coverage with flat fan nozzles
- Saves pesticides (up to 20%)
- Reduces spreading of contagious pests and diseases as it minimizes walking in the field
- Boom can be fitted to battery and petrol-run sprayers
- Boom sprayers can offer employment opportunities to rural youths for providing service to farmers

Do's and Don'ts while spraying and after spraying

Do's	Don'ts
✓ Wear gloves when handling nozzles	× Clean a nozzle with an abrasive implement
✓ Clean a nozzle with water and a light brush	× Clean a nozzle by blowing through it with your mouth
✓ Protect nozzles from blockages with the use of recommended filters	× Use damaged or worn nozzles
✓ Frequently clean nozzles	× Use fine spray drop sizes on a windy day
✓ Calibrate nozzles and sprayer every season	
✓ Replace the nozzle if damaged	
✓ Follow any product label recommendations	
✓ Change nozzles as necessary depending on the crop, growth stage and product mode of action	

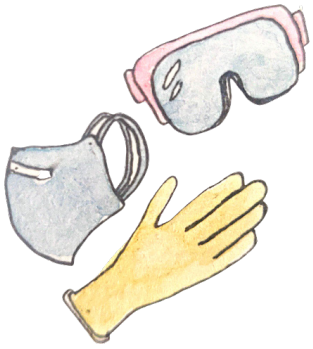
Five Golden Rules For Safe Use Of Crop Protection Products

1 Exercise Caution Always

2 Read and Understand the Product Label

3 Practice Good Personal Hygiene

4 Take Care Of and Maintain Application Equipment



5 Wear Appropriate Personal Protective Clothing and Equipment (PPE)

Wrong and unsafe application leads to health risks

It also leads to higher costs! Farmers are unable to work and may incur medical costs for hospitalization.

- Deposition of pesticide should be 100%, not more and not less
- Pesticide losses due to drift or deposition on soil results in reduced effect
- Higher use results in more costs and threat non-targets and environment

Precautions

- Check sprayer for leaks with clean water (always before use)
- Calibrate sprayer output (at least once per season)
- Ensure an even and uniform application
- Clean the sprayer after each use

Spraying Quality

- Steady height
- Steady speed
- Constant pressure
- Calibrate sprayer
- Avoid drift because it causes:
  - Contamination of the environment and farmer
  - Loss of product
  - Damage possible to neighbouring crop
- Ensure good coverage
- Check distribution
- Droplet size
- Avoid runoff

After Application

- Clean the sprayer properly
- Spray, when possible, the cleaning water over the crop instead of letting it run off
- Store leftover pesticides in a safe place
- Bath/shower after application
- Change clothes
- Wash clothes separate from other clothes
- Don’t enter the field for 1-2 days.

HARVESTING, GRADING AND TRANSPORTATION

12

The days to maturity are commonly recognized for tomatoes. This will vary with cultivar and growing conditions.

Most tomato varieties will produce mature fruit 70-125 days after planting. As a guideline, tomatoes usually ripen 6-8 weeks from the fruit set but this varies by region.

The following stages of ripeness:

- **Immature Green:** the seeds are not fully developed, there is no locular jelly surrounding the seeds, the fruit colour is pale green, and the flesh is hard.
- **Mature Green:** the fruit is fully grown, the light green colour at the blossom end has changed to a yellow-green cast, the seeds are surrounded by locular jelly, and the flesh is hard.
- **Breaker:** about one-quarter of the surface at the blossom end shows some pink colour.
- **Pink:** about three-quarters of the surface is pink, and the flesh is firm.
- **Full-Ripe:** the fruit is nearly all red or pink, and the flesh is still firm.
- **Over-Ripe:** the fruit is fully coloured, and the flesh soft.

When to harvest will depend on how the fruit will be handled and used. Fresh market fruit for local consumers can be picked red, while fruit that will be transported long distances should be harvested at the mature green or breaker stage.

Conventionally grown tomatoes sold in wholesale markets are often picked at the mature green stage and ripened in storage with the use of ethylene gas. Harvesting for the fresh market is almost always done by hand.

Good field management during harvesting is critical in order to pack a high-quality product. Tomatoes at the breaker stage or riper are susceptible to bruising during handling.

Tomatoes are harvested at several stages – mature green, turning pink, red ripe and over-ripe. The stage of harvesting depends upon the purpose for which the tomatoes are harvested. Generally, tomatoes are harvested at mature green to turning stage for distant marketing. For fresh consumption, pink to light red tomatoes are preferred.

Tomatoes ripen on the plant itself. However, ripening may take place after harvesting also. For artificial ripening, tomatoes are harvested at the mature green stage or at the turning stage and kept at room temperature (15-25 °C). Then ripening takes place with the evolution of endogenous ethylene. There is some weight loss with artificial ripening, but this is negligible. Artificial ripening is required when there is very low or high temperature. To enhance the ripening on plants, Ethrel at a rate of 1,000-2,000 ml/l should be sprayed at the start of ripening. Application of Ethrel at the immature stage of fruits causes injury to the fruits and plants.

The harvested tomatoes produce an adequate quantity of ethylene which is sufficient for their ripening. If tomatoes are kept in an air-tight place and ventilation is not allowed, there is no need to apply Ethephon for their ripening. However, Ethephon can be sprayed on plants to harvest the early crop.

For distant transportation, wooden boxes, crates, polythene bags or baskets, are used for packing tomatoes.

COST OF CULTIVATION

13

Tomato cultivation is influenced by many factors such as the season, quality of seeds/ seedlings, weather, prevailing price in the market, market availability etc. Hence, it is difficult to arrive at cost of cultivation.

Following is an illustrative example from the project experience: (Note: Transportation cost is not included)

Particulars	Unit	No of Units	Unit cost (Rs.)	Amount (Rs)
Land Preparation				
a. Ploughing	hours	2	1,000	2,000
b. Harrowing/Rotavator	hours	1	1,500	1,500
c. Bed Preparation	hours	1	1,500	1,500
d. Drip Laying Woman	days	2	400	800
e. Mulching sheet	600 meters	6	3,000	18,000
f. Mulch laying and Hole making	man days	9	400	3,600
Drip Installation				
(Amortised for one season)			**12,000**	**12,000**
Fertilizers and FYM				
FYM	trucks	2	2,000	4,000
Fertilizers		1	21,800	21,800
Application cost	man days	10	400	4,000
Planting Seedlings & Transplanting				
Planting Seedlings	nos	6000	**1**	**6,000**
Transplanting	man days	4	**400**	**1,600**
Weed Control				
Metribuzin	100 g	2	**350**	**700**
Spraying application	man days	1	**400**	**400**
Manual weeding	man days	12	**400**	**4,800**
Propping Staking material				
Propping Staking Material	sticks	1200	**10**	**12,000**
Erection cost	man days	6	**400**	**2,400**
Threads	kg	3	**400**	**1,200**
Trellising labour	man days	12	**400**	**4,800**
Irrigation				
	man days	3	**400**	**1,200**
Plant Protection				
Chemicals		1	**15,000**	**15,000**
Application cost	man days	5	**400**	**2,000**
Harvesting				
Labour cost	man days	40	**200**	**8,000**
Total Expenses				**127,300**
Fruit Yield	**kg**	**30000**		
Gross Income		**30000**	**10**	**300,000**
Net Returns				**172,700**

Here the cost of cultivation comes to Rs. 4.50/kg considering the average yield of 30 t/acre. This can go up to 40 t/acre. The average price considered for the produce is Rs. 10. Many times it may go up to Rs. 40/kg and as low as Rs. 3/kg.

CASE STUDY

14

Mechanisation in Tomato Cultivation

Introduction

He has 4 acres of land and is growing tomato crops for the last 15 years. Prior to the GIC project intervention, he has been facing many problems in tomato cultivation such as the outbreak of diseases, pest attacks, less yield etc.

He has been cultivating on his own experiences without much proper scientific approaches.

Problems Faced in Tomato Cultivation

- Purchase of seedlings from any nursery without knowing what healthy seedlings is
- Planting of 8000-10,000 saplings per acre with narrow spacing between the rows and plants.
- Flood irrigation in a row
- Application of high nitrogen in the form of urea and less potassium
- Not following any precautionary measures for pest and disease control.
- Not practicing proper bedmaking and use of mulch sheets.
- He was getting a yield of 25-30 t/acre with the use of hybrid

Innovative Solutions from GIC project

- Selection of healthy seedlings from quality nurseries.
- Plantation of 5000 to 6,000 thousand saplings per acre with wider spacing i.e 5-6 ft from row to row and 2-2.5 ft from plant to plant.
- Watering the crop through drip irrigation system.
- Giving less nitrogen and more potassium in a balanced way as per the recommendations /soil test reports.
- Staggered planting to de-risk from price volatility.
- Planting on raised bed method with mulching sheets

Farmer Details

Name: Venkatesh KM
Village: P Kodihalli
Hobli: Yagati
Taluk: Kadur
District: Chikkmagaluru

Result and Conclusion

By associating with the GIC project, he became a member of Bhumiputra Farmers Study Group which is formed in P. Kodihalli village with 20 tomato farmers. He got several training and exposure visits under the project and started to implement them in his field. He realised the importance of precautionary measures to control pest and disease attacks and reduce the cost of cultivation.

List of Abbreviations

AFC	Agriculture and Finance Consultants
B	Boron
BMZ	German Federal Ministry for Economic Cooperation and Development
Ca	Calcium
CEC	Cation-Exchange Capacity
Cu	Copper
DAP	Days After Planting
EC	Electrical Conductivity
Fe	Iron
FYM	Farm Yard Manure
GAP	Good Agricultural Practices
GIC	Green Innovation Centres for the Agriculture and Food Sector
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HEEU CoH	Horticulture Education and Extension Unit College of Horticulture
IIHR	Indian Institute of Horticulture Research
IIVR	Indian Institute of Vegetable Research
IPM	Integrated Pest Management
K	Potassium
LE	Larval Equivalent
Mb	Molybdenum
Mg	Magnesium
Mg	Manganese
N	Nitrogen
NABARD	National Bank for Agriculture and Rural Development
NHRDF	National Horticulture Research and Development Foundation
NIPHM	National Institute of Plant Health Management
NPK	Nitrogen, Phosphorus, Potash
NPV	Nuclear Polyhedrosis Virus
NSKE	Neem Seed Kernel Extract
P	Phosphorus
pH	Power of Hydrogen
PPE	Personal Protective Clothing and Equipment
PSB	Phosphate Solubilizing Bacteria
PTD	Participatory Technology Development
S	Sulphur
UHSB	University of Horticultural Sciences
WG	Water Dispersible Granules
WP	Wettable Powder
Zn	Zinc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