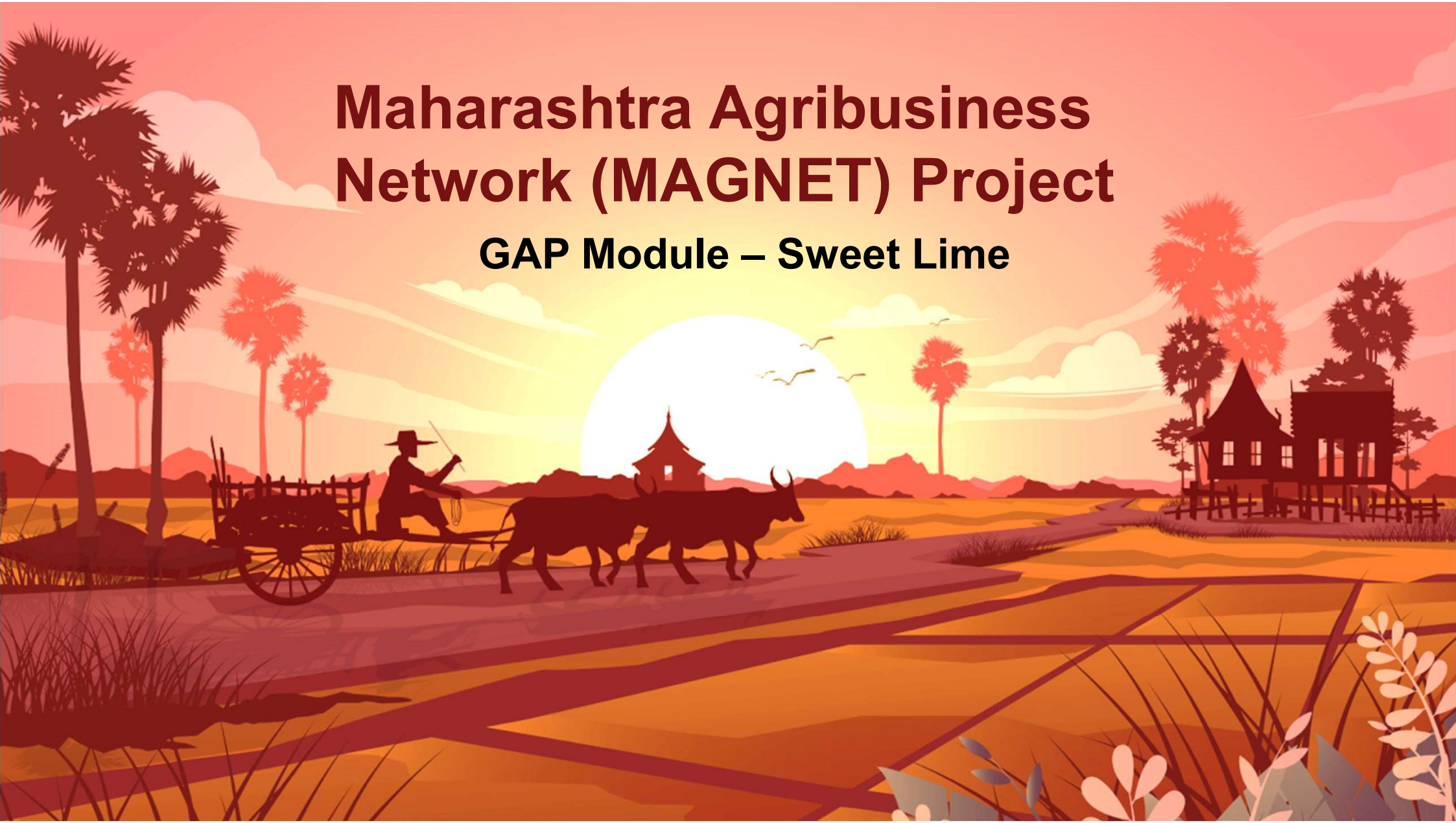
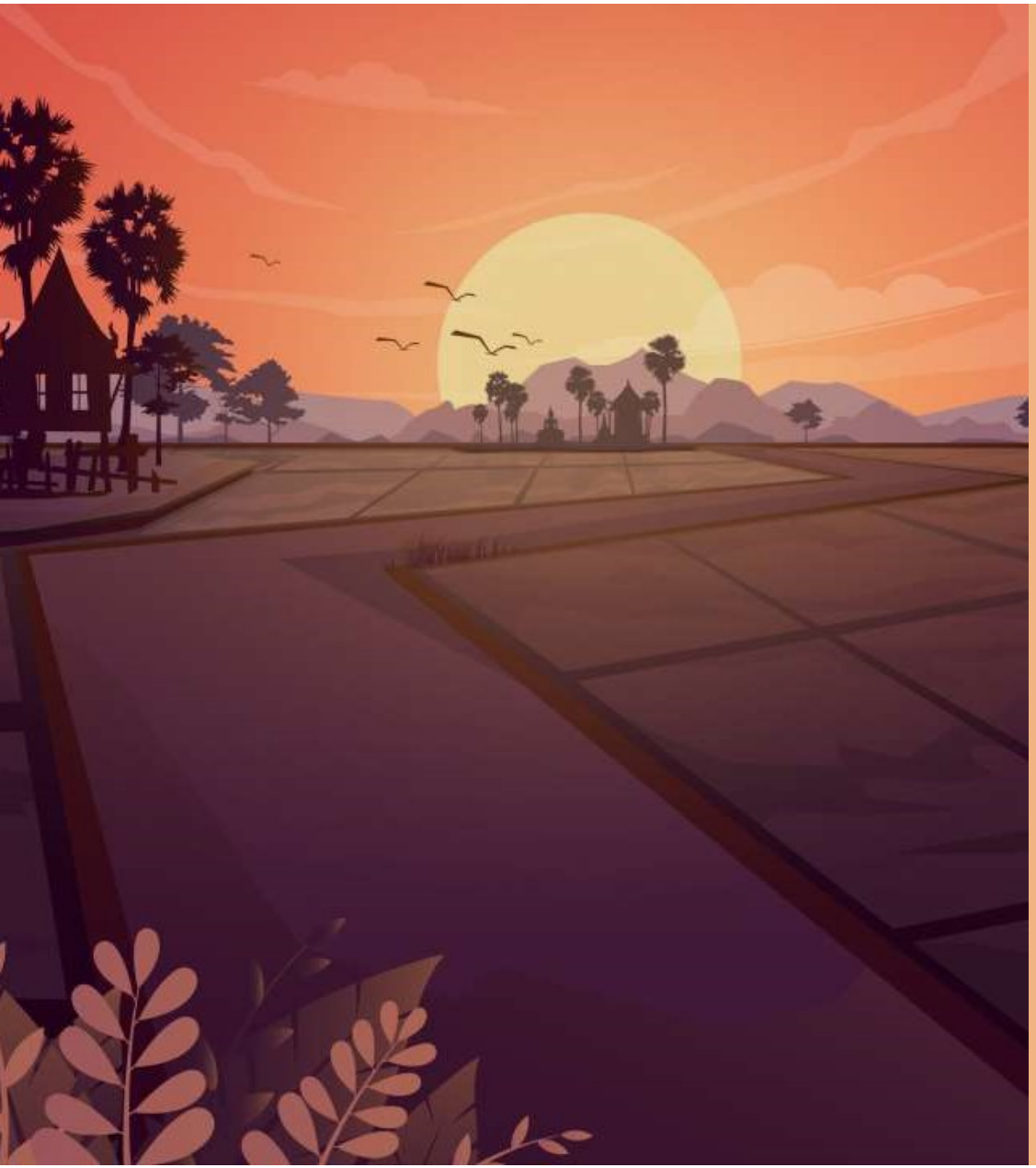


Maharashtra Agribusiness Network (MAGNET) Project

GAP Module – Sweet Lime



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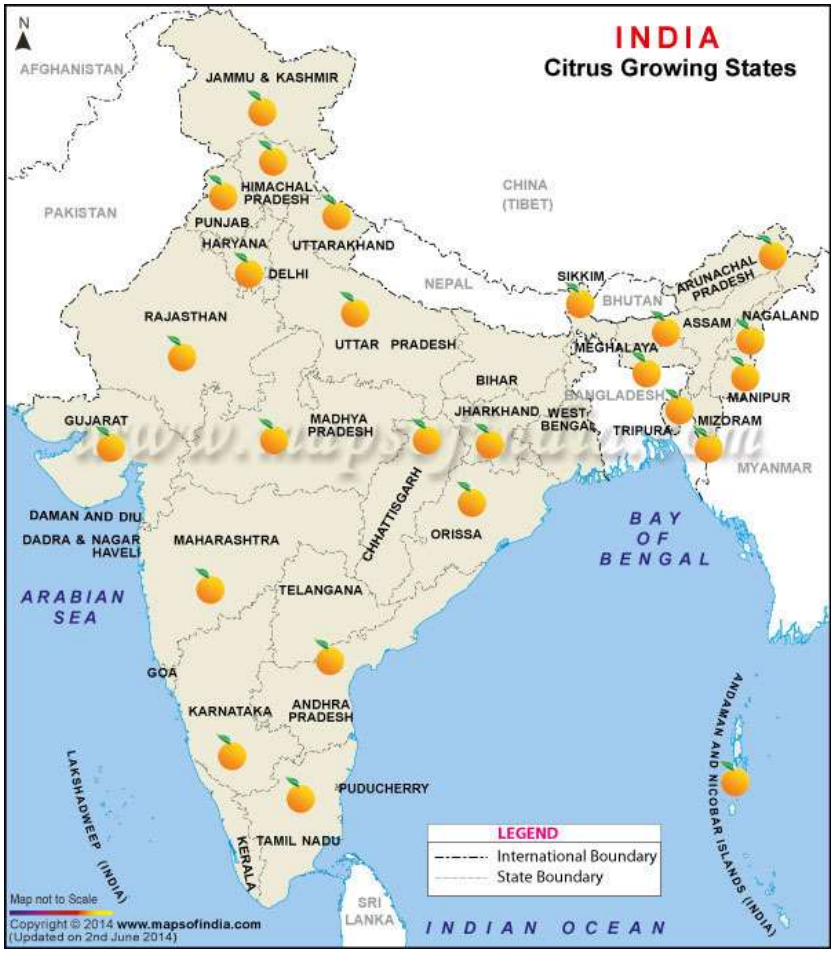
About Sweet Lime

- **India** is one of the largest producer of Sweet lime along with Brazil, China, Mexico and Spain
- Sweet lime production in India occupies 6th position among all the fruits with total annual **3.2 million tonnes**

Family: Rutaceae
Scientific name: Citrus × Citrus limetta
Common name: Mosambi (Maharashtra), Sathgudi, Batavian (Andhra Pradesh) and Malta and Jaffa (Punjab)

India: Sweet Lime Production Scenario

- In India, Andhra Pradesh is having largest area under sweet lime cultivation followed by Maharashtra.
- The total production of sweet lime is concentrated mainly in the Andhra Pradesh (2663), Maharashtra (671) and Telangana (506) MT respectively in India
- Andhra Pradesh is having high productivity (24 MT/Ha), . In comparison, Maharashtra's productivity is quite low at 11.14 (MT/Ha).
- The low productivity in Maharashtra can be attributed to poor irrigation infrastructure in the crop growing region and improper implementation of Good Agriculture Practices



Maharashtra: Sweet Lime Production Scenario

- In Maharashtra state, sweet lime production is concentrated in Aurangabad, Jalna and Nanded district in Marathwada region.
- Aurangabad and Jalna are the major producing districts in Maharashtra in 2019-20. Aurangabad has the highest area under cultivation with 21.25 thousand hectares and producing 297.50 thousand tonnes of sweet lime.
- Commercial processing juice is the need of the hour.

Sweet Lime: Benefits

Stimulates Appetite:

The daily intake of sweet lime improves hunger, especially in those suffering from anorexia – an eating disorder that leads to extreme loss of body weight

Regulates Digestion:

Eating few slices of sweet lime daily improves the intestinal functioning and treat indigestion.

Antioxidant Rich:

Sweet lime boasts active compounds that are super rich in antioxidants like kaempferol, flavonoids, quercetin, limonoids and vitamin C, that can aid the body in beating various health conditions.

Healthy Bones :

Loaded with vitamin C and folic acid, Sweet lime strengthens bones and improves the functioning of joints.

Heals Jaundice:

Ayurvedic practitioners recommend including sweet lime in daily diet as it digests easily and improves liver function.

Prevents Scurvy:

Sweet lime, rich in vitamin C helps in curing this condition and restores normal health at a faster pace.

Varieties

Varieties of Sweet Lime

Mosambi

Malta (Red)

Sathgudi

Varity	States
Mosambi	Maharashtra, Andhra Pradesh
Malta (Common)	Punjab and Haryana
Malta (Red)	Punjab
Sathgudi	Andhra Pradesh

Mosambi variety is tolerant of low drought conditions and thus can survive in less than recommended irrigation.

Soil and Climate

Deep well drained loamy soils are the best for the cultivation of sweet lime. Plant is highly sensitive to water-logged soils.

The pH of soil should be 6.5 to 7.5 and EC of water should be less than 1.0

Sweet lime can be grown even upto an elevation of 900 m above mean sea level

A dry climate with about 50-75 cm of rainfall from June-September and with well defined summer and winter season is ideal

The extreme of temperature are necessary for achieving higher yield. Temperature 25^0 C is most ideal and extreme cold and high temperatures are determinate

Planting

Budded plants are the best planting materials. Healthy and vigorously growing budlings budded on Rangpur lime root-stock from a certified nursery have to be selected.

The ideal season for cultivation of sweet lime is July to September.

Normal spacing - 5 m x 5 m, 5.5 x 5.5 m

Plant population - 400/330 per ha

Pits of 1 meter cube are dug in square system at prescribed spacing and filled with a mixture of top soil, 15-20 kg farmyard manure and 500 g Super phosphate.

Immediately after planting irrigate copiously. Irrigations may be given once in 10 days. Avoid water stagnation near the plant during monsoon and cyclone periods.

Pruning and Training

In order to allow the growth of a strong trunk, initially shoots upto 40 - 50 cm from the ground level should be removed. The centre of the plant should remain open. Branches should be well distributed to all sides. Cross twigs and water suckers are to be removed early. The bearing trees require little or no pruning. All diseased, injured and drooping branches and dead wood are to be removed periodically.

- **Control of Fruit drop**

Early and pre-harvest fruit drop is common in citrus fruits. To control this physiological disorder, it is a better to give three sprays of 2,4-D at 10 ppm (1g/100ℓ), one at the time of flowering, the second one month after fruit set and the third one month before harvest which is beneficial and increases the yield considerably minimizing the fruit drop .

- **Bahar Treatment**

There are three flushes Ambe bahar (Dec-Jan), Mrig Bahar (June-July), Hastha Bahar (Sept-Oct) in sweet lime. Main season of Bahar is August-September which comes to fruiting in March which is having very good market price. The second season practiced for Bahar is Nov-Dec where fruits comes to harvest in the months of July-august.

Manure and Fertilizer

Nitrogen has to be applied in two doses during March and October. However Farm yard manure, Phosphorous and Potash are to be applied in October.

Fertilizers are applied in a circular band at a radial distance of 120 cm from the tree trunk region

Deep placement or application of fertilizers at two to three areas in a basin should be avoided

In fact, the maximum activity in sweet lime plantation was found within a depth of 25 cm and in acid lime they are more surface oriented, 80-95% being located in top 10cm.

Integrated Nutrient Management (INM):

Manures and Fertilizers	1st year (Kg/plant)	Annual increase (kg/plant)	From 6th year (kg/plant)
FYM	20	5	30
N	0.1	0.1	0.5
Phosphorus	0.05	0.05	0.25
Potassium	0.025	0.025	0.25

Micronutrient:

Spray solution containing Sulphate of Zinc (0.5%), Manganese (0.05%), Iron (0.25%), Magnesium (0.5%), Boron (0.1%) and Molybdenum (0.003%) once in 3 months at the time of new flush production.
In addition to that apply 25 g in each of Sulphate of Zinc, Manganese and Iron per tree per year.

Weed Control

- In order to make weed free orchard, persimmon tree basins should be cleared off from any useless plants. Hand weeding can be carried out whenever needed. Mechanical control or chemical control by using herbicides are practiced. You can mulch the trees for controlling weed growth and preventing water loss.

Intercropping

- Leguminous crops like soybean, gram, groundnut, cow peas, french bean, peas etc., can be grown in sweet lime orchards which may bring extra income to farmers.
- Intercropping needs be done during the initial three-four years after planting.

Good Agricultural Practices (GAP)

Pre-Planting Measures

Site selection

- Land or site for production should be selected on the basis of land history, previous manure applications and crop rotation.
- The field should be away from animal housing, pastures or barnyards.
- Farmers should make sure that livestock waste should not enter the produce fields via runoff or drift.

Manure storage and sourcing

- Manure should be stored as far away as practical from areas where fresh produce is grown and handled.
- Physical barriers or wind barriers should be established to prevent runoff and wind drift of manure.
- Manure should be actively composted so that high temperature achieved by well-managed, aerobic compost can kill most harmful pathogens

Pre-Planting Measures

Manure Application

- Manure is a valuable source of nutrients, but it also can be a source of human pathogens if not managed correctly.
- In order to reduce this risk manure should be composted properly.
- Top dressing of manure should be avoided, and it should be incorporated into soil prior to planting.
- Manure should be applied at the end of the season, preferably when soils are warm, non-saturated, and cover cropped.
- If manure is being applied at the start of a season, then the manure should be spread two weeks before planting.
- Manure should be applied in the planting year only. The long period between application and harvest will reduce the risks.

Production Measures

Irrigation water quality

- The water used for irrigation or chemical spray should be free from pathogen.
- However, potable water or municipal water is not feasible for extensive use for crop production.
- Hence, surface water used for irrigation should be quarterly tested in laboratory for pathogen.
- Farmers can filter or use the settling ponds to improve water quality

Irrigation methods

- Drip irrigation method should be used, whenever possible to reduce the risk of contamination.
- Plant disease levels also may be reduced and water use efficiency is maximized with this method.

Production Measures

Field sanitation and animal exclusion

- Farmers should stay out of wet fields to reduce the spread of plant or human pathogens.
- Tractors that were used in manure handling should be cleaned prior to entering produce fields.
- Animals, including poultry or pets should not be allowed to roam in orchard areas, especially close to harvest time

Worker facilities and hygiene

- Ideally, farm workers should be provided clean, well-maintained and hygienic toilet facilities around the farming areas.
- Farmers should get proper training to make them understand the relationship between food safety and personal hygiene.
- These facilities should be monitored and enforced.

Harvesting Measures

Clean harvest aids

- The harvester should be washed and rinsed under high pressure.
- All containers should be sanitized before harvest.
- The containers should be properly covered, when not in used to avoid contamination by birds and animals.

Worker hygiene and training

- Good personal hygiene is particularly important during the harvest of crops.
- Sick employees or those with contaminated hands can spread pathogens to produce.
- Employee awareness, meaningful training and accessible restroom facilities with hand wash stations encourage good hygiene.

Harvesting Measures

Worker hygiene

- Hands can contaminate fresh fruits and vegetables with harmful microbes.
- Packing area should be cleaned and sanitized.
- Encourage proper use of disposable gloves on packing lines.
- General sanitation of orchard, containers and equipment should be done to prevent contamination.
- Use of wood products i.e., bins and ladders should be reduced.

Monitor wash water quality

- Potable water should be preferably used in all washing operations.
- Clean water should be maintained in dump tank by sanitizing and changing water regularly.
- Use chlorinated water and other labeled disinfectants to wash fresh fruits

Harvesting Measures

Sanitize packinghouse and packing operations

- Loading, staging, and all fruit contact surfaces should be cleaned and sanitized at the end of each day.
- Exclude all animals, especially rodents and birds from the packinghouse.
- Wash, rinse and sanitize the packing line belts, conveyors, and fruit contact surfaces at the end of each day to avoid buildup of harmful microorganisms.
- Packaging material should be stored in a clean area.

Pre-cooling and cold storage

- After harvesting, fruits should be quickly cooled to minimize the growth of pathogens and maintain good quality.
- Water bath temperature for cooling should not be more than 10^0F cooler than the produce pulp temperature.

Harvesting Measures

Transportation

- Proper cleanliness of the transportation vehicles should be ensured before loading.
- Farmers have to make sure that fresh fruits are not shipped in trucks which have carried live animals or harmful substances.
- If there is no alternative then these trucks should be washed, rinsed, and sanitized before transportation.

Post-harvest Management of Sweet Lime

Factors Influencing the Postharvest Management

The quality of sweet lime fruits will not be improved after harvest, but only preserved with adequate practices hence, it is essential that optimum quality of sweet lime to be produced in the field

The preharvest operations are important because they influence the quality of the fruit very significantly after harvest

Pre-harvest practices such as the use of fertilizers, pest control, growth regulators, climatic conditions like wet and windy weather and tree conditions, influences the fruit quality at harvest and in postharvest and the potential storability of the fruit

The application of potassium fertilizers extends the postharvest life of the fruit

Maturation and Ripening

Citrus ripen gradually and are slow to drop from the tree

Peel color changes during ripening, but that change is a function of climate more than ripeness, and a poor indicator of maturity.

Mature fruit vary in size, even on the same tree.

Maturity Indices

The development of the fruit is strongly affected by temperature, and maturity of the rind and of the flesh of the fruit are not synchronized

The maturity of sweet lime is considered on the basis of juice content, the contents of soluble solids contents (SSC) also called Total Soluble Solids (TSS) or Degree Brix (Brix), titratable acidity (TA) and SSC:TA ratio.

The content of SSC is very practical guide for harvest in the field, especially in rural areas where growers do not have any other means to measure maturity index objectively. A handheld refractometer, which is relatively inexpensive, can give an almost exact picture of fruit maturity in the orchard

The change of fruit color from light green to yellow-orange in most of the fruits on a tree is also very simple criterion for judging maturity. The size of fruit cannot be a reliable criterion for maturity since fruit size may remain small depending on the bearing and nutritional status of the plant.

Maturity Indices

Brix (% sugar)

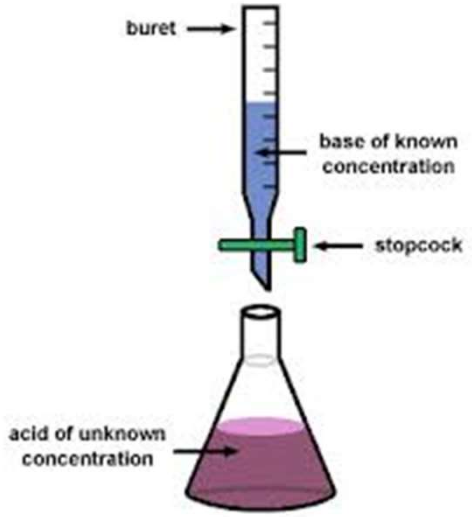
Sugar content of juice is measured with hand refractometer. It increases slowly during maturation

Acid content

Acid content is measured by titration with sodium hydroxide (NaOH), and decreases with maturation

Brix/acid ratio

Juice content: Extraction juice and determine its volume



Maturity Indices: % brix, % Acidity

Citrus fruit	% Brix
Oranges	10 - 14%
Grapefruit	8 - 10%
Tangerines	12 - 16%
Lemons and limes	<10 %

Citrus fruit	% Acid
Oranges	0.5 - 1.5%
Grapefruit	1.0 - 2.0%
Tangerines	0.5 - 2.0%
Lemons & limes	6.0%

Harvesting

Generally, fruits should be harvested after 32-36 weeks from fruit is set

Fruits should be protected from direct sunrays immediately after harvest

It is best to harvest sweet limes on a clear, sunny day with low humidity. The fruit should be harvested as soon as the dew has evaporated.

Harvesting should not be carried out during wet weather or early morning when fruits are turgid and can easily be bruised, leading to decay during subsequent handling

Sweet limes are mostly handpicked using ladders and other support materials hence, care should be taken to reduce damage and physical and mechanical injuries

Harvesting (Contd.)

It is recommended to use clippers to clip the fruit from the tree to avoid damage

Fruits should be clipped in such a way that the button remains intact with the fruits

Care should also be taken not to pick immature or over mature fruits

Longer stalk portion of the clipped fruits left during harvesting may pierces into other fruits and causes injuries that paves the way for attack of wound pathogen

Therefore, while clipping, the stalk should be cut close to the fruit, so as to preclude it from puncturing the rind of other fruit during harvesting and handling

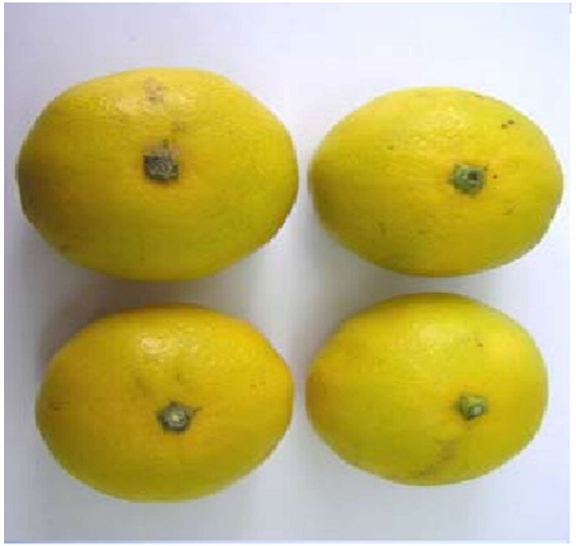
Post-harvest Operations

Curing or conditioning

- After harvest or chemical treatment, fruit should be kept in the shade for a few days before they are packed, transported or stored. This treatment (curing or conditioning) reduces the water content of the peel, thus reducing cell activity in the peel, reduces the breaking of oil glands in the skin, and therefore reduces the deterioration of the quality of the fruit.
- The time needed for the curing/conditioning depends on the ambien temperature, the length of time the fruit is to be stored, and the thickness of the peel.
- Sweet lime need a longer period of curing if they are to be stored for a long time, or if they have a thick peel. On average, it takes from three to seven days to reduce the fruit weight by about 3%.
- A higher water content than this may cause condensation inside the plastic bag, leading to stem rot. Water loss may cure minor wounds on the peel and reduce the incidence of diseases during storage.

De-greening

- The process of de-greening constitutes degrading the green color (the chlorophyll) of the peel without influencing the internal quality of the fruit.
- The de-greening process involves exposing green-skin fruit of uniform grade to low levels of ethylene (usually between 1 ppm to 10 ppm) at 20°C to 25°C and 90-95% relative humidity for 12 hours to 3 days, depending on the temperature and the ethylene concentration used.
- Fruits should not be washed before de-greening.
- Ethephon (at 500 ppm for 1 minutes), an ethylene-releasing liquid compound, can also be used by dipping the fruit in a tank of sanitized water at room temperature.
- It is always better if the ethylene treatment is done immediately after harvest and prior to waxing.



Selection, grading, packing and packaging

- Better packaging is necessary to minimize losses and to achieve the most economical use of conveyance.
- During the packing process, the immature, overripe, damaged and diseased fruits should be sorted out, and only sound fruits should be packed.
- Some of the damages that can result from using the inappropriate package (inappropriate material or inappropriate size package) are cuts or punctures, shock/impact, compression, vibration, heat damage, chilling or freezing damage and chemical contamination

Selection, grading, packing and packaging

- In India that fruits for local markets are packed in sacks, bags, bamboo baskets and wooden boxes.
- For export, fruits should be packed in 2 pieces (telescopic) corrugated fiberboard boxes of three ply or five ply.
- Normally a box size of 49.5 x 30 29.5 x 17.5 cm having10 kg capacity is recommended. The boxes must have 5% area punched as holes for ventilation.
- To immobilize the movement of fruits inside the box, three ply wax treated dividers having ventilation holes should be used.

Selection, grading, packing and packaging

- Quality and hygienic cushioning material should be used to protect fruits from impact, injury and compression.
- During packaging, fruits should not be packed loosely in order to avoid shaking of fruits, which leads to friction and thereby causing damage.
- The filling should be done in wooden boxes or cartons with little pressure so that during transit the pack structure does not get loose.
- Shrink-wrapping is a technique in which heat shrinkable poly films should be used to wrap the individual fruit and over wrapping of trays.
- Polyethylene is commonly used as the wrapping material, as it is relatively inexpensive

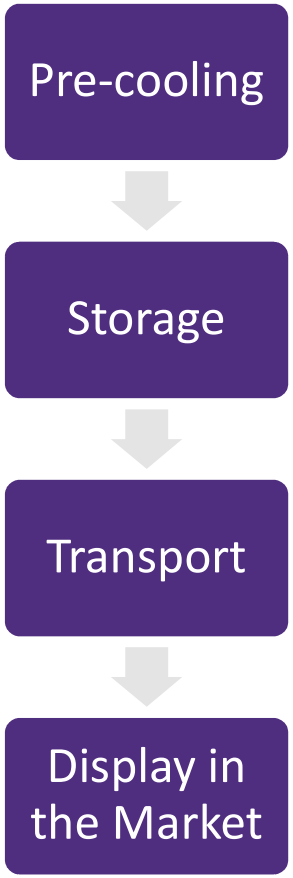

Sealed boxes tied with coconut fibre ropes


Fully filled boxes


Paddy Straw between the layers

Cold chain

- Cooling of the fruit not only extends storage life by reducing the rate of physiological change, but also retards the microbial growth.
- Even low-cost cooling or refreshing the product is better than no cooling at all.
- For short-term storage and during transit period, 10°C is adequate to minimize the decay of the fruits.
- Maintaining at high temperature causes rapid moisture loss, flavor deterioration, and decay of the fruits.
- It is preferable to store fruits at their optimum relative humidity (RH) of 90% to 95%. At a lower relative humidity, the peel becomes thin, dry, and shriveled.



Storage

- The storage structure should be easily accessible and located on a raised well-drained place.
- It should be protected from excessive humidity, excessive heat, direct sunrays, and pests.
- The storage structures should be properly cleaned and fumigated before storing fruits.
- There should be no left over, cracks, holes and crevices in structure, which may harbor insects.
- Before storage, the fruits should be properly cleaned and dried, and the damaged fruits should be discarded to avoid quality deterioration and pest attack.
- To control infestation and to maintain hygienic condition of the storage, the new and old stock should be stored separately.
- There should be proper ventilation and circulation of air to avoid accumulation of gases such as carbon dioxide, ethylene, etc., and regular inspection of stored fruits should be carried out to check infestation.

Sweet Lime Processing and Value-Added Products

Processed products from Sweet Lime

Products : Pure Juice (Mosambi and similar varieties), Squash, RTS Segment, Jam, Essential oil

Integrated Pest Management

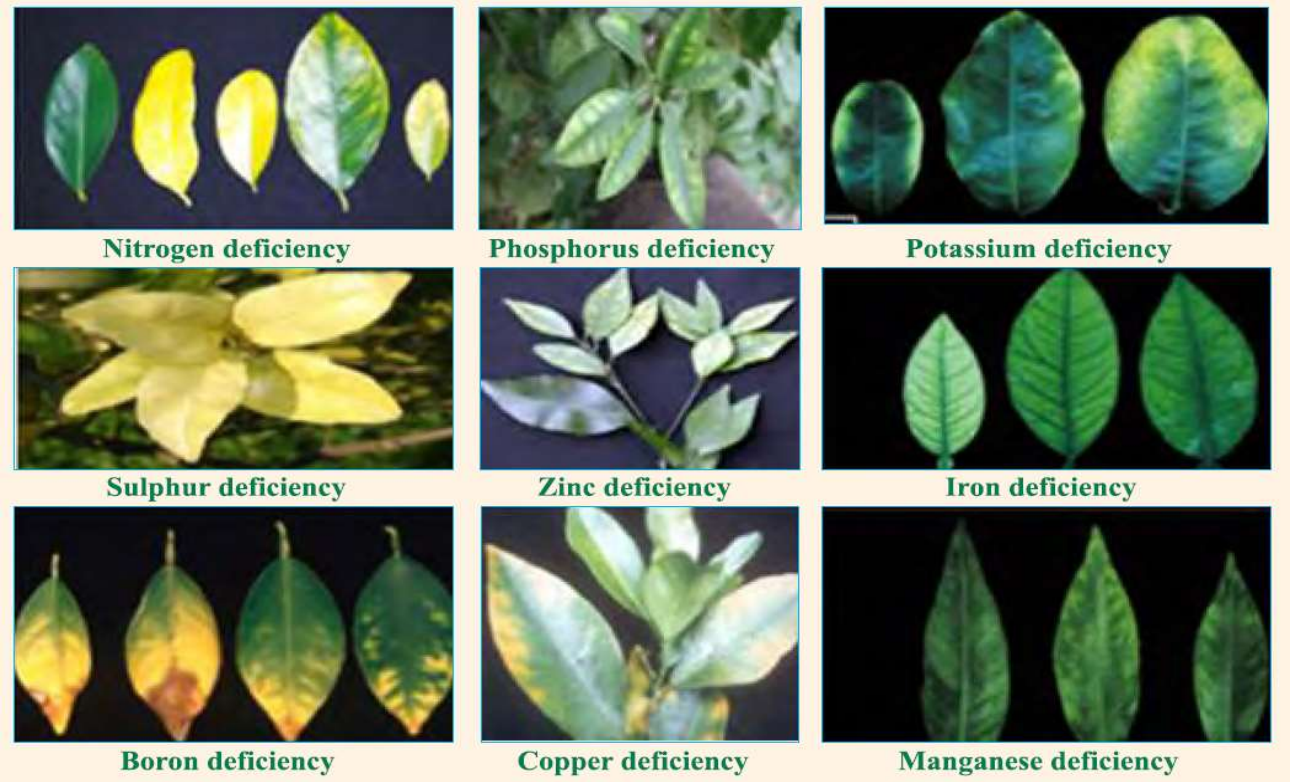
Important Pest and Diseases

Important Pests of Sweet Lime

Important Pest and Diseases (Contd.)

Important Diseases of Sweet Lime

Important Pest and Diseases (Contd.)



Nutrient Deficiencies of Sweet Lime

Physiological Disorders

Chilling Injury

- Chilling injury (CI) is a major physiological disorder of citrus fruits induced by low but non-freezing temperature, which imposes limitations for extending the storage life of the fruit. Refrigerated storage of sweet lime fruit for extended period of time may lead to CI.
- The symptoms of CI in citrus fruits are mainly exhibited as pitting, brown staining, red blotches, scalding, rind staining, watery breakdown, soft glazed continuing lesion of mandarins, sunken tissues, damage to the styler end, necrosis on the rind and increased decay incidence.
- Sweet lime are chilling sensitive and it can occur if temperatures fall below 5°C. Severity of chilling injury increases with decreased temperatures below 5°C for longer durations. Sweet lime are susceptible to granulation or section drying, which depends on fruit variety and maturation stage.
- To mitigate the problem of CI some non-chemical and chemical methods have been developed. Postharvest heat treatments (HT) are predominantly used to reduce the development of CI symptoms during cold storage and cold quarantine treatment. Heat treatments (HT) include hot air (HA) and hot vapours (HV). Postharvest handlings such as HT, rinses or brushing, vapour heat and HA are applied commercially in order to enhance chilling tolerance, in addition of reducing decay development, delayimg ripening and eradicate insects.

Physiological Disorders (Contd.)

Other physiological disorders include:

- **Stem-end rind breakdown**, where symptoms include shriveling and peel injury around the stem due to aging.
- **Rind staining, where** this disorder results from overmaturity at harvest, and it can be reduced by preharvest application of gibberellic acid that delays senescence.
- **Oil spotting (Oleocellosis), which commonly occurs as a result of h**rvesting and handling turgid sweet lime and can result in the release of oil that damages the surrounding tissues. Thus, sweet lime should not be harvested when fully turgid such as early in the morning and soon after rain or irrigation, and conditioning treatment should be practiced.

Postharvest diseases

Postharvest diseases and disorders generally develop due to infestations before harvest. Losses from postharvest diseases are both quantitative and qualitative. Most of the diseases are caused by fungi and bacteria.

- **Stem-end rot** develops as latent infections on the fruit button before harvest and begin growth through the core after harvest, and decay develops unevenly at the stem and stylar ends resulting in uneven margins.
- **Anthracnose** is characterized by brown peel lesions, appears on early-season mandarins that have undergone lengthy de-greening periods.
- **Brown rot** develops from infections that take place in the field before harvest, has a characteristic rancid odor and tan lesions that quickly overtake the entire fruit under optimum conditions for the pathogen.
- **Green and Blue Mold** develop as a result of wounds caused during the harvesting and handling process.

Insects and quarantine measures

Insects, especially fruit flies, are major causes of losses, and are important restrictions for transport of the fruit to different regions especially for export to certain countries..

Cold treatment, approved as a quarantine treatment for sweet lime infested with fruit flies, consists of storage of fruit below at 0ºC to 2.2ºC for up 10 to 16 days, depending on temperature and type of fruit fly.

However, because of susceptibility to chilling injury, sweet ime may need to be held at higher temperatures of 10 to 15°C for about one week prior to cold treatment to increase resistance to chilling injury

Important Notice:

The information on performance of recommendations given in this handbook holds good only when used under optimum conditions. Their performance may either change in due course of time due to several factors or can vary under different systems of management. Mishandling/negligence of the user can also result in damage/loss/non reproducibility of results.

The user is advised to contact their nearest KVK and refer to the latest Ad-hoc list for information on banned chemicals and other nationally-issued directives.

महत्वाची सूचना:

या हँडबुकमध्ये दिलेल्या शिफारशींच्या कामगिरीची माहिती इष्टतम परिस्थितीत वापरली जाते तेव्हाच चांगली राहते. त्यांची कार्यक्षमता एकतर अनेक कारणांमुळे योग्य वेळी बदलू शकते किंवा व्यवस्थापनाच्या वेगवेगळ्या प्रणालींमध्ये बदलू शकते. वापरकर्त्याच्या चुकीच्या हाताळणी / निष्काळजीपणामुळे परिणामांचे नुकसान / पुनरुत्पादन न होणे देखील होऊ शकते. वापरकर्त्यास त्यांच्या जवळच्या केव्हीकेशी संपर्क साधण्याचा आणि प्रतिबंधित रसायने आणि इतर राष्ट्रीय-जारी निर्देशांच्या माहितीसाठी नवीनतम तदर्थ यादीचा संदर्भ घेण्याचा सल्ला देण्यात आला आहे.

Thank You

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