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Protected cultivation of Tomato

What is protected cultivation???

- ✓ Protected cultivation practices can be defined as a cropping technique wherein the micro climate surrounding the plant body is controlled partially or fully as per the requirement of the vegetable species.
- ✓ With the advancement in agriculture various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged.
- ✓ It is a potential approach to increase the vegetable production.
- ✓ It involves protection mainly from adverse environmental conditions such as temperature, frost, hails, scorching sun, heavy rains & unusual snow at different production stages.
- ✓ Besides, temperature, relative humidity, wind velocity & soil conditions play major role in the design of protected structures for growing vegetable crops.

Commonly used protected structures

- Poly houses
- Net houses
- Lath houses
- Plastic houses
- Shade houses
- Hot beds
- Cold frames
- Plastic low tunnels

Benefits of protected cultivation

- ✓ Vegetables crops can be grown under unfavorable agro-climatic conditions.
- ✓ Certain vegetable crops can be grown round the year in a particular place.
- ✓ Crop yields can be several times higher than those of under open field conditions.
- ✓ Quality of produce is superior.
- ✓ Higher input use efficiencies are achieved.
- ✓ Management of insect-pests, diseases, weeds, etc. is easier under protection.
- ✓ Agricultural income per unit area increases.
- ✓ It provides an excellent opportunity to produce vegetables for export.
- ✓ Protected structures are ideally suited for production of genetically engineered & micro-propagated vegetable varieties & hybrids.

Protected cultivation of tomato

Introduction

- ✓ Tomato (*Solanum lycopersicum* L.) is the second most important vegetable crops of Peru – Ecuador origin (Rick, 1969) after potato.
- ✓ It's belongs to the family *Solanaceae*. Because of its wider adaptability and versatility, tomato is grown throughout the world either in outdoors or indoors.
- ✓ Among vegetables, tomato is the first crop grown in greenhouse worldwide.
- ✓ Demand for tomatoes is usually strong due to the vine-ripe nature & general overall high level of eating quality.
- ✓ It is universally treated as "**productive"** as well as "**protective food**" having medicinal value, too.
- ✓ As they are high in nutrient contents, they can be used as raw vegetables in sandwiches and salads or it can be processed to several products like puree, paste, soup, powder, juices, ketchup, whole canned fruits etc.

More about tomato

Botanical Name	*Solanum lycopersicum* L.
Other names	Wolf apple, Vilayati Baingan, love apple
Family	Solanaceae
Origin	Peru and Mexico
Ch. No. (2n)	24
Type of fruit	Berry
Cluster of flower	Truss
Seed contains	24% oil
Ancestor of tomato	*Lycopersicum esculentum* var. cerasiforme
Mode of Reproduction	Self-Pollinated
Acid	Citric and Malic
Red Colour	Lycopene
Alkaloid	Tomatine
Toxic compound	Saponine
1st hy. cv. (India)	Karnataka Hybrid (by IAHS from Bangalore) in 1973
Transgenic Varieties	Flavr Savr, Endless Summer, Rosato
Photoperiodism	Day Neutral
Photosynthetically	C3

Types of tomato

Determinate	**Indeterminate**
Main axis ends in a floral bud.	Main axis ends in a Vegetative bud
Main axis ends in a flower cluster. (Nitrogen req. is high) bush type	Main axis does not ends in a flower cluster. (Nitrogen req. is low) veining type
Self topping habit	No self topping habit and growth is continuing.
Does not require staking, training & pruning	Require stacking, training & pruning
At each and every internode inflorescence is there.	At each and every third internode inflorescence is there.
Suitable for open field & mechanized harvesting	Polyhouses
Distance : 75 x 45 cm	90 x 45 cm
Trusses are separated by <3 leaves	Trusses are separated by 3 leaves
Life span short	Life span long
E.g. HS- 101, GT-2, GT-1, AT -3, JT – 3 etc.	E.g. Pusa Ruby, Pusa Divya, Sioux, GT-1, Best Of All, Tip Top, Pant Bahar, Pant T-1, Pant T-3

Which types of tomato suitable for greenhouse condition? Why?

- ✓ Indeterminate type of tomato most suitable for green house condition.
- ✓ For its continuous growth habits and more life cycle.
- ✓ Same time vegetative and reproductive stages occurs.
- ✓ Set new fruit and ripen fruit all at the same time throughout the season.

Soil and Climate

- ✓ Requires relatively warm season and cannot tolerate frost.
- ✓ For plant growth 20-26 ^{0} C temperature is optimum.
- ✓ Lycopene is highest at 21-24 ^{0} C

- ✓ Carotenes develop rapidly at higher temperature.
- ✓ Soil which is well drained, rich in organic matter, with good water holding capacity with pH of 6.0-6.5 is good for tomato cultivation. Sandy loam is best.

Temperature requirements during different growth stages

Growth stage	Temperature (^{0}C)		
	Minimum	Maximum	Optimal
Germination	11	34	16-29
Vegetative growth	18	32	21-24
Fruit setting (night / day)	10 / 18	20 / 30	13-18 /19-24
Formation of lycopene	10	30	21-24
Formation of carotene	10	40	21-32
Optimum relative humidity in glasshouse crops Range from 60- 75%.			

CO_2 concentration

- ✓ High levels (600 to 1000ppm) of carbon dioxide are maintained in the greenhouse atmosphere to increase photosynthesis, growth rate and crop yield.
- ✓ Without the use of the other chemical its increased by closed the greenhouse curtains in the evening (near 4.00 p.m.) and its opening next day after sunrise.
- ✓ Its increased CO_2 concentration and increased ultimately yield.

Preparation of land

- ✓ Soil sterilization
- ✓ Bed preparation
- ✓ Planting distance
- ✓ Mulching
- ✓ Proportion of root media 1:1:1:1 (soil, organic matter, sand and rice husk)

Soil Sterilization

- ✓ By following methods:
- ✓ Fumigation
- ✓ Soil solarisation
- ✓ Steam pasteurization (not in India)
- ✓ **Fumigation**
- ✓ A few chemicals like, Methyl bromide, Chloropicrin (tear gas), Formaldehyde and Hydrogen peroxide are used for fumigation.
- ✓ Formaldehyde is a commonly used chemical to sterilize the root medium.
- ✓ Drenching of root medium with formaldehyde mixed with water 1:10 is the usual practice.
- ✓ After drenching, the soil or root medium will be covered with plastic film. It is found very effective to check the serious problems like damping-off, nematodes etc.
- ✓ For drenching Formalin is used at the rate of 7.5 lit for 100 sq mt *i.e.* 37.5 lit of Formalin will be required for 500 sq. mt polyhouse area.
- ✓ After drenching, planting is done after two weeks, this method is not effective against nematodes and it should not to be used in a standing crop.
- ✓ **Steam Pasteurization**
- ✓ The root medium should be loosened before pasteurization.
- ✓ This will help the movement of steam though the pores and transmit the heat rapidly within the medium.
- ✓ The root medium should not be dry and if dry, addition of water speeds up the rate of pasteurization, though excess watering slows down the speed of pasteurization.
- ✓ Moistening of root medium a week or two prior to pasteurization is the best procedure, which breaks the dormancy of many unmanageable weed seeds, and then pasteurization destroys them easily.
- ✓ **Solarisation**
- ✓ The soil or root medium can be disinfected in warmer climate by covering soil with transparent plastic in hot summer days.

- ✓ This will increase the heat of the soil to a great extent and destroy many soil borne pathogens and insects.
- ✓ However, solarisation coupled with fumigation works better to control effectively a good number of soil borne insects and diseases.

Bed preparation

- ✓ During bed preparation firstly sterilized soils are washed by water to remove the extra chemicals through leaching.
- ✓ And open the soil for 2-3 days in sunny period.
- ✓ Raised beds of following dimensions are prepared.
- ✓ Top width- 90cm
- ✓ Height - 40 cm
- ✓ Bottom width of bed – 100cm

Mulching

- ✓ The mulch reduces evaporation of water from the soil and prevents compaction of the soil surface.
- ✓ White (reflective) plastic mulches are recommended to control weeds, converse moisture, reduce humidity and improve light conditions and also to avoid soil contact and prevent diseases.

Seed rate and treatment

- ✓ For raising the seedlings in nursery bed 300 - 400 g/ha seeds are required.
- ✓ Hybrid seeds are very costly so it should be sown in plug tray, which require only 100-120 g.
- ✓ To avoid damping off disease, treat the seed with Tricoderma @ 5-10 g/Kg seed or Carbendazim 2g/Kg seed.

Preparation of seedlings

- ✓ The treated seeds are dried in shade for 30 minutes and then sown in the plug tray at the depth of 0.5 cm.
- ✓ Spray 19-19-19 along with other micronutrients regularly on alternate days.
- ✓ Seedlings are ready for transplanting 4-5 weeks after sowing.

Transplanting time

- ✓ Seedlings are ready for transplanting 4-5 weeks after sowing.
- ✓ Generally when seedlings attain 5-6 true leaves they are ready for transplanting.

Planting season/ time and method

- ✓ Under greenhouse conditions tomato crop can be grown for long duration (10-12 months) by cooling during summer months (April to June or July) and by heating the greenhouse during peak winter months (December and January) in northern parts of the country.

Planting distance

- ✓ Determinate type: 90 cm x 60 cm, 90 cm x 45 cm, 75 cm x 45 cm

Steps in plantation of tomato

- ✓ Adequate moisture must be available in the soil at the time of plantation.
- ✓ The seedlings should be dipped in Bavistin (0.2%) solution at the time of plantation.
- ✓ Plantation to be done by making holes or trenches on bed in a zigzag method.
- ✓ Planting should be avoided during the hottest period of the day/year & should normally be done during late in the evening.

Care after plantation

- ✓ The soil around the plants must be kept humid but not soaking wet.
- ✓ Irrigate the plant with hose pipe immediately after plantation.
- ✓ During periods with strong sunshine or high temperature, the young plants must frequently be given an over head spray of water to assist establishment & reduce post planting losses.
- ✓ For first three weeks the irrigation should be done only by using hose sprayer & later on irrigation should be done by drip system.

Criteria for selection of variety

- ✓ High yielding and indeterminate type having resistance/ tolerance to Nematodes, Fusarium Wilt, Verticillium Wilt, TLCV, etc.
- ✓ High percentage of number of fruits, freedom from green shoulder, self life and TSS.

- ✓ Consumer preference with respect size, shape and colour.

Varietal selection

- ✓ **Improved Varieties:** Arka Saurabh, Arka Vikas, Arka Ahuti, Arka Ashish, Arka Abha , Arka Alok, HS101, HS102, HS110, Hisar Arun, Hisar Lalima, Hisar Lalit, Hisar Anmol, KS.2, Narendra Tomato 1, Narendra Tomato 2, Pusa Red Plum, Pusa Early Dwarf, Pusa Ruby, Co-1, CO 2, CO 3, S-12, Punjab Chhuhara, PKM 1, Pusa Ruby, Paiyur-1, Shakthi, SL 120, Pusa Gaurav, S 12, Pant Bahar, Pant T3, Solan Gola and Arka Meghali.
- ✓ **F1 Hybrid Varieties:** Arka Abhijit, Arka Shresta, Arka Vishal, Arka Vardan, Pusa Hybrid 1, Pusa Hybrid 2, COTH 1 Hybrid Tomato, Rashmi, Vaishali, Rupali, Naveen, Avinash 2, MTH 4, Sadabahar, Gulmohar and Sonali.

Our university experiment on tomato

- ✓ In which grown a exotic hybrids of tomato.
- ✓ Totally 4 types hybrids grown: two are from Turkey like, 102536 and Pera Dure. Another two are from China like, EG-4121 and EG-4160.
- ✓ In which China hybrids are very susceptible to blight and not well perform.
- ✓ Hybrids of Turkey are resistant to leaf curl virus and well perform in our nature.
- ✓ Dose of the fertilizer were 350:350:350 NPK kg/ha (water soluble, by NCPAH).

Water requirement

- ✓ Now a day's Drip method of irrigation is practiced.
- ✓ Frequent irrigation is essential for plant growth, fruiting and yield.
- ✓ The crop should be irrigated at daily.
- ✓ However during summer more irrigation is required due to higher surface evaporation.
- ✓ Drip system is highly economical and produces quality tomato.

Fertigation

- ✓ After planting, initially given 19:19:19 and 12:61:0 at alternate days up to the flowering time.
- ✓ Flowering time given 13:0:45 and fruiting time given 0:0:52 for the flowers & seed formation.
- ✓ In fertigation time firstly 5-10 minutes given only water and than given the fertilizer solution. (time as per the area).
- ✓ Lastly, 3-5 minutes again given the water because of to washing out the drip.

Fertilizer dose of tomato

- ✓ For variety : 150:100:50 kg of NPK/ha
- ✓ For hybrid : 250:250:250 kg of NPK/ha.
- ✓ South Gujarat : 120:80:70 kg of NPK/ha.
- ✓ By NCPAH: 350:350:350 kg of NPK/ha by water soluble fertilizer

Cultural operation

1. **De-suckering**

- Side shoots (suckers) develop between each compound leaf and stem.
- These suckers are removed, leaving only the main stem as a growing point.
- For this reason, side shoots are usually not pruned until they are few cm long, and can be easily distinguished from the main stem.

2. **Stacking**

- After transplanting immediately plant, stems should be secured to nylon/plastic (high – density) twine, and quality of twine should be ensured.
- Twines are hung from horizontal wires at least 3 m about the ground.
- Horizontal wires must be sturdy enough to support the weight of all plants in the row.

3. **Training**

- Plants should be trained as single (main) stem.
- The plants can be supported with the help of plastic twine loosely anchored around the base of the plants (non slip loop) at one end.
- The same plastic twine is tied to overhead support wires (12 to 16 gauge) running along the length of the row.

- Overhead wires should be at least 3m above the surface of beds and should be firmly anchored to support structures.
- Tie the plant with the help of plastic twine in inclined position to the overhead support wires.
- Twine should be wrapped clockwise around the plant, with complete swirl every three leaves.
- Plastic twine should not be wrapped around fruit clusters. When plants reach the overhead supporting wires, unite the twine and lower the vines and twines at least three feet (once in two weeks).
- After lowering, vines should lean in one direction in one row, vines in extra twine for this purpose when initially tying wines.
- **Training systems:**
- Single stem
- Two stem
- Three stem
- Spacing: 60 x 45 cm (NCPAH)

4. **Topping**

- Six weeks before the anticipated crop termination date, the growing point and small fruit clusters at the top of the plant are removed this operation is called Topping.
- Topping is carried out for rapid fruit development and improving size of already-set fruit in the lower part of the plant.
- To avoid sunburn the shoots are left to grow at the top.

5. **Pollination**

- Although Tomato is highly self pollinated crop, but aided pollination is needed in the greenhouse grown Tomatoes due to limited air movement & high humidity.
- Bumble bees are the perfect pollinator, even under environmental stress conditions like low & high temperature.
- Bee hives are usually active for 6 to 10 weeks where after these should be replaced.
- In electric or battery- powered vibrators, flower clusters are vibrated or shaken for a second or two.
- This method is not effective on cloudy days because the humidity prevents pollen dehiscence even with vibration.
- However, it might be a good idea to pollinate on every sunny day during winter season.
- This practice is done twice a day at 10:00 to 11:00 AM. {Humidity is lower at this time thus facilitating pollen dehiscence}.
- In addition, fruit size seems to be maximized by pollination during these hours.

6. **De leafing**

- When vines are lowered, leaves touching the ground are removed to prevent diseases development.
- The amount of de-leafing that occurs higher up the plant varies between growers.
- The purpose of de-leafing higher up the plant stem is to increase light penetration and air circulation.
- Typically, all leaves are removed below the lowest fruit cluster, which has not been harvested.
- De leafing also helps to make more carbohydrates available to the fruit trusses, thereby increasing yield. This operation is carried out in all types of tomatoes.

7. **Fruit thinning**

- Small, undersized fruit at the end of cluster (distal fruit) are always removed, as these will generally not grow to marketable size and reduces the size of the other fruits on the cluster.
- Specially in Beefsteak tomatoes in initial development, when the plants are young.

Using of growth regulators

✓ The growth regulators can be used to increase fruit set at high and low temperature to reduce the leaf curl incidence.

✓ The flower dipping in PCPA (Parachloro-Phenoxy acetic acid) 30 ppm at the fully open

stage to increase the fruit set at low and high temperature.

- ✓ The application of Cycocel (500ppm) on the plants in nursery 3-4 days before transplanting another spray of it 25-30 days after transplanting.
- ✓ It reduces the leaf curl incidense.

Other growth regulators are given in table;

Chemicals	**Common name**	**Dose (mg/l**	**Effective**
2-Chloroethylphosponic acid	Ethephon	200-nt spray	Flowering induction, better rooting and setting of plants
2,4 Dichlorophenoxy acetic acid	2,4-D	2-5 as or ray	Increase fruit set, earliness and parthenocarpy
3- Indole Butyric acid	IBA	50-	Increase fruit set
3 Indole acetic acid	IAA	Folia	For good fruit size and yield

Harvesting

- ✓ Harvesting of tomatoes starts after 60-75 days the total crop period.
- ✓ Harvesting is done daily or alternate day depending on market distance and choice.
- ✓ Harvesting at the proper stage of maturity, careful and minimal handling of the produce will help in maintaining better fruit quality and reduce storage losses.
- ✓ Harvesting is generally done during morning and evening hours.
- ✓ Avoid harvesting immediately after fogging to check the disease and pest under control and to maintain better keeping quality of fruit.

Yield

- ✓ Truss tomatoes-25-30 kg/sq.m.
- ✓ Cherry tomatoes-15-20 kg/sq.m
- ✓ Variety : 20-30 ton./ha
- ✓ Hybrid : 60-70 ton./ha

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