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Advanced Techniques for Quality Seed Production in Tomato (*Solanum Lycopersicum* L.)

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Tomato (*Solanum lycopersicom*) is an annual or short lived perennial pubescent herb and greyish green curled uneven pinnate leaves. The flowers are off white bearing fruits which are yellow in colour. It is a self pollinated crop. The major tomato producing states are Maharashtra, Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Madhya Pradesh and Assam. The family Solanaceae includes more than 2,600 species, many of which are important for humans. There are several important vegetables included in this family, such as tomato, potato, sweet pepper, brinjal and chili (*Capsicum* spp.) Tomato is one of the most popular and widely grown vegetables in the world ranking second in importance to potato in many countries. Tomato is consumed either as raw or cooked and is also very important crop for processing in the form of soups, juice, ketchup, puree, paste and powder. Tomato adds variety of colours and flavour to food. Tomato is very well known for lycopene pigment, pink and yellow colours are due to presence of anthocyanin and carotene pigments. Tomato is rich source of ascorbic acid, which varies from 15-31 mg per 100 g of fresh weight. Tomato also provides minerals like calcium, iron, magnesium, phosphorus and sodium. Tomato is also rich in medicinal value. The pulp and juice is digestible, promoter of gastric secretion and blood purifier. It is also considered to be intestinal antiseptic. It is one of the richest vegetables, which keeps our stomach and intestine in good condition. Tomato seed production relies on its biological nature as a self-pollinating plant. Because flowers contain both male and female parts, ensuring genetic purity requires careful field isolation and controlled extraction to produce high-quality, viable seeds.

Origin

Tomato is one of the most popular and widely grown nutritious vegetable in the world. Most of the cultivated types of tomato belong to *Lycopersicon esculentum mill*. Cultivated tomato is generally accepted to have originated in the tropical Americas, its origin home being probably in Mexico or Peru. In India, tomato has become a very popular vegetable especially during the last 50 years. The crop is of recent origin and first report of tomato was from Italy in 1544. Later spread was fast and the crop is grown throughout the length and breadth of world

Nutritive value and medicinal use

Tomato occupies a leading position in list of protective foods since it is a rich source of minerals like calcium (48 mg / 100g), sodium (12.9 mg), trace elements, copper (0.19 mg), vitamins like vitamin A (900 IU), vitamin C (27 mg), vitamin B complex (thiamine), essential amino acids and healthy organic acids like citric, formic and acetic acids. The attractive red colour of fruit is due to lycopene and yellow colour is due to carotenes. Peculiar flavour of tomato is due to presence of ethanol, acetaldehyde and a number of volatile flavour components found in fruit. Different forms of tomatine, a steroidal glycoalkaloid, are

identified from various parts of plant. Tomato is a good appetizer and its soup is a good remedy for preventing constipation.

Taxonomy

Botanical name of tomato is Solanum lycopersicum (lycos = wolf and persicon = peach). Genus Lycopersicon is divided into two subgenera

a. Eulycopersicon (Red fruited and self compatible)

b. Eriolycopersicon (Green fruited and self incompatible)

(a). Eulycopersicon includes two species, L. esculentum (Solanum lycopersicum) with large fruits and L. pimpinellifolium (New name Solanum pimpinellifolium) with small fruits born in clusters.

(b). Eriopersicon mainly consists of wild sp like L. hirsutum (S.habrochaites), L. peruvianum,(S. peruvianum) L. pissisi, L. glandulosum, L. cheesmani (S. cheesmani) etc.

The genus divided of Lycopersicon into following two groups based on their ability to cross with cultivated tomato: Esculentum complex (crossable with cultivated tomato) - L. esculentum, L. pimpinellifolium, L. cheesemani and L. hirsutum Peruvianum complex (Not crossable with cultivated tomato) - L. peruvianum, L. chinense.

Solanum lycopersicum

Solanum pimpinellifolium

L. chessmanii

L. hirsutum

Botany

Tomato (Lycopersicon esculentum Mill.) belongs to the family Solanaceae and genus Lycopersicon chromosome number is (2n=24). The genus includes 12 species. Although in tropical South America where it is native, tomato is a perennial crop. It is usually grown as an annual for both fruit as well as seed purpose. The plant is a large and heavily branched with alternate, pinnate compound leaves.

Tomato is characterized by two types of plant : **(i)** Determinate type inflorescence occurs more frequently in almost every internode until terminate ones are formed and elongation ceases at this point **(ii)** Indeterminate type-inflorescence cluster occurs at every third internode and the main axis continues growing indefinitely.

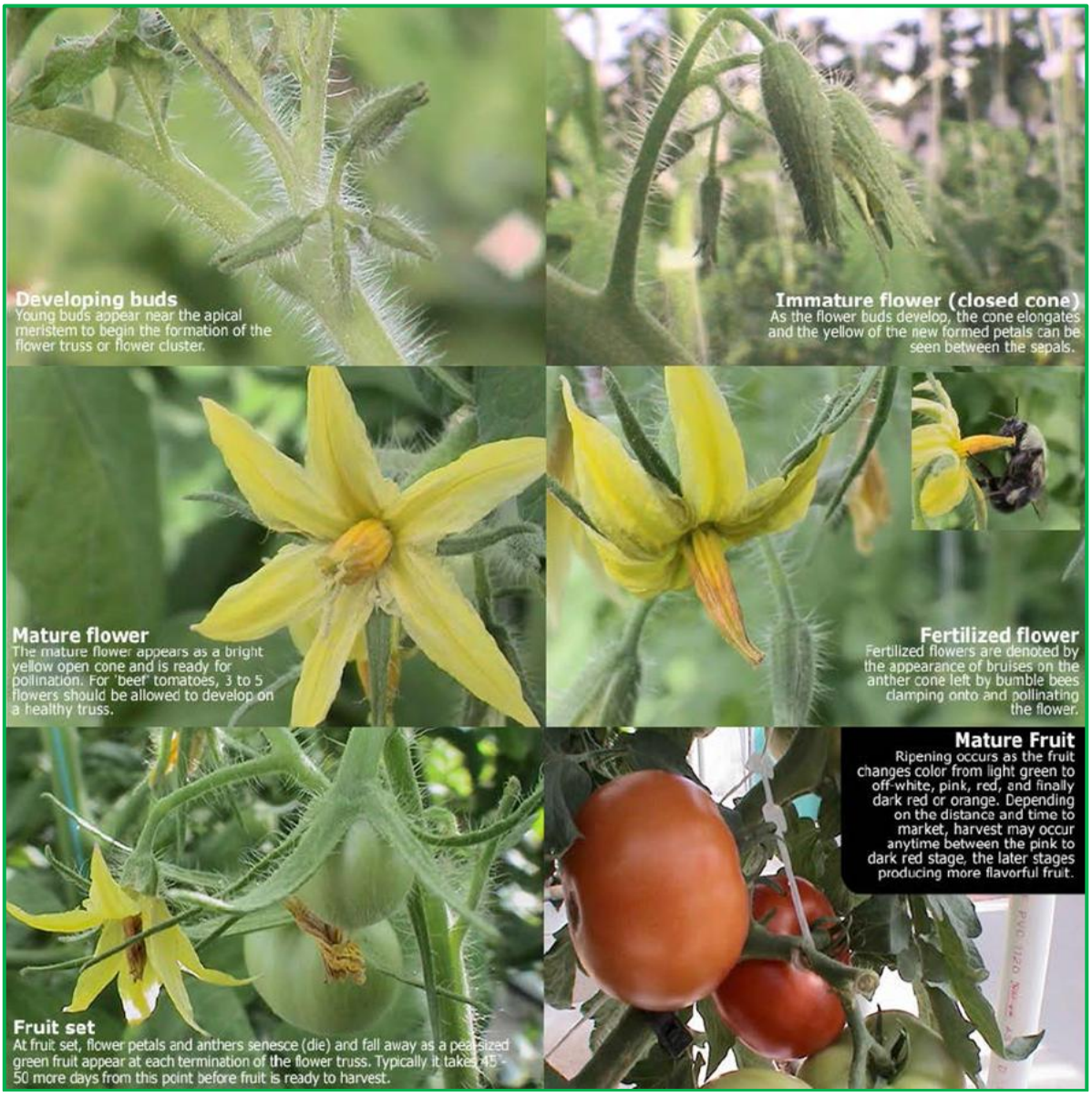
Flower Biology

Bright yellow, first flower bud at terminal meristem of the main stem while 2nd and 3rd on the lateral side of the pedicels of the first and second flower, respectively, arranged alternately on the leaf and right side of the inflorescence peduncle.

Floral Biology

- ❖ Anthesis starts around 6 a.m.
- ❖ Flower continues to open up to 11 a.m.
- ❖ Peak of anther dehiscence is between 8-11 a.m. depends on initiation of sun shine, atmospheric temperature and humidity.
- ❖ Range 18-250C and remain viable 2-5 days.
- ❖ Stigma becomes receptive 16-18 hrs before anthesis and retains the receptivity up to 6 days after Anthesis i.e. shortly before the flower withers.
- ❖ This causes self pollination. Pollen retains viable for 2-5 days at temperature of 18-250C in desiccators
- ❖ Pollen remains viable for 6 months.
- ❖ Fertilization takes place 24-50 hrs after pollination.

Flowers are borne in racemose cyme and flower cluster is known as 'truss' and its position is extra axillary. Flowers are hermaphrodite, pendulous, pentamerous and hypogenous. Stamens are six in number and inserted on throat of corolla tube and anthers are convent around style Tomato is a self pollinated crop due to hermaphrodite flowers, introvert stigma, internal and synchronized anther dehiscence, and stigma receptivity. Self fertilization occurs when pollen grains are shedding during growth of style through anther corn. In warm regions of the country, some amount of crossing was observed when stigma protrudes out the level of anthers.



Field Selection and Preparation

Selection of fields for tomato seed production is utmost important for maintaining produce quality and quantity. The following points should be kept in mind before going to the selection of field for tomato seed production.

- ✓ The soil of selected field should varies from sandy loam to silty loam with pH value ranges from 6.0 to 7.0
- ✓ Upland Field should be preferred for tomato to avoid the water logging during rainy season with well drainage facilities.
- ✓ Selected field had not grown continuous solanaceous crops within the past 3-4 years.
- ✓ Select sites that have good air movement (to reduce disease) and that are free from problematic weeds.

For preparation of land the field is ploughed to fine tilth by giving four to five ploughing with a sufficient interval between two ploughing. Planking should be done for proper levelling. The field is then divided into beds and channels. Well-decomposed FYM is thoroughly incorporated at the time of land preparation.

Climatic

Tomato is a day neutral warm season crop, which cannot tolerate frost. Cool and dry weather is preferred by the crop and optimum temperature is 21-28oC during day and 15-20oC during night. Night temperature is more critical than day temperature. High temperature results in exerted stigma, dryness of stigma, burning of anther tip, poor pollen dehiscence, low pollen viability and slow pollen tube growth leading to low pollination and fruit set. Incidence of viral diseases also will be more at high temperature. Optimum temperature for colour development of fruit is 21-24oC. Development of colouring pigment, lycopene will be hampered above 27oC. Seed germination and pollen germination are adversely effected below 10oC. Based on night temperature requirement for fruit set, tomato varieties are classified into three.

a) Normal set varieties: Set fruits at 15-20^{o}C.

b) Hot set varieties: Set fruits above 20^{o}C Ex.(Philipine, Punjab Tropic, Pusa hybrid 1)

c) Cold set varieties: Set fruits below 15^{o}C Ex. (Pusa Sheetal, Avilanche)

Tomato cannot withstand water logging. Hence well drained fairly fertile soil rich in organic matter is preferred. It is moderately tolerant to acid soil having pH 5.5 and ideal pH requirement is 6-7oC.

Method of seed production: Seed to Seed.

Stages of seed production: Breeder seed - Foundation Seed I - Foundation Seed II - Certified Seed

Important Varieties

- ❖ **Arka Aditya:** The variety is a semi-determinate type. Dark green foliage with round, firm and medium-large fruit (90-100g). Variety is resistant to TLC, bacterial wilt and early blight. Fresh market variety. The average fruit yield is 60-65 t/ha.
- ❖ **Arka Vishesh (H-391).** The variety is resistance to TLC, bacterial wilt and early blight. Variety is semi-determinate type with dark green foliage and has joint less pedicle. Can be cultivated in summer, kharif & rabi season. It yields up to 43.3-90 t/ha. Firm, deep red, oblong to medium large fruit (90- 100g).
- ❖ **Arka Apeksha (H-385):** Variety has triple disease resistance (Tomato Leaf Curl Disease, bacterial wilt and early blight). It is suitable for processing and has TSS (4.7° Brix), acidity (0.36%) and lycopene (14.15mg/100g fresh weight). It can yield up to 43 to 90 t/ha.
- ❖ **Arka Rakshak:** It was the first F1 hybrid with triple disease resistance. Variety has square-round, large (90-100g), deep red coloured and firm fruits. Good for fresh market and processing. It can yield up to 75-80 t/ha in 140 days.
- ❖ **Arka Ashish:** Variety has fruits that are oval, firm, thick fleshed and has 2 locules. Excellent fruit colour (lycopene 10 mg/100g) with TSS 4.8%. It is suitable for processing. It is tolerant to powdery mildew and fruit cracking. It can yield up to 38 t/ha in 130 days.

- **Punjab Varkha Bahar-1:** The variety has determinate habit with dense dark foliage. Fruits are round, dark red and firm. The variety takes 90 days after transplanting to maturity. The variety is resistant to tomato leaf curl virus and yields 538 q/ ha.
- **Punjab Varkha Bahar-2:** The variety is semi-determinate type with dense light green foliage. Fruits are round dark red fruits of medium firmness. It takes 100 days from the date of transplanting for attaining maturity. Resistant to tomato leaf curl virus. Variety yields 541q/ha.
- **Pusa Rohini:** This variety developed at IARI, New Delhi. Plants determinate, fruits red, round, smooth, medium sized (70 g), thick pericarp (0.6 cm), longer shelf-life, better market appeal and suitable for long distance transportation and processing. This variety mature in 120 days andyielded 41.2 t/ha
- **Pusa Sadabahar:** Plants of this variety are determinate, prolific bearer; fruits red, oval to round, small, smooth and attractive, suitable for growing under a wide range of temperature (80C-300C) and yielded 25-35 t/ha
- **Pusa Uphar:** Plants are indeterminate, prolific bearer, upright, compact with dark-green foliage; fruits in bunches with 4-6 fruits per bunch, attractive round, medium sized, thick-skinned and uniform ripening with yielded 37 t/ha tomato fruits.
- **Pusa Sheetal:** Developed at IARI, New Delhi**.** Determinate, good growth, leaves serrated and green, fruit flattish round, smooth uniform in maturity, heavy yielder (30-32.5 t/ha). Sets fruits at low temperature hence suitable for early sowing in Indo-Gangetic Plains
- **Pusa Ruby:** This variety developed by IARI, New Delhi. Early cultivar, fruits with yellow stem end, uniform ripening, heavy yielder it can give about 25.0 t tomato fruits in hectare area. Variety suitable for both spring summer and autum-winter season.
- **Pusa Gaurav:** Developed at IARI, New Delhi. Leaves serrated and light green, fruits red with yellowish tinge, smooth and egg shaped with yellow stem end, uniform ripening. Suitable for canning and long distance transportation.

Hybrid Vigour

Tomato is a classical example for exploitation of hybrid vigour in vegetables. Increasing consumer demand, better emasculation and pollination processes, more seeds per fruit, diversified use and scope for combining large number of favourable genes in F1 coupled with easiness in cultivation makes the crop ideal for heterosis, breeding. Quite a large number of F1 hybrids with specific attributes like yield, earliness, uniformity, high quality, suitability to long distance transport, storage and processing, adaptability to adverse conditions, resistance to biotic and abiotic stresses have been developed by public sector research organizations as well as private sector seed companies. With the adoption of new seed policy by the Government of India in 1988, a large number of private seed companies entered in vegetable research and F1 seed trade. F1 hybrids developed and marketed by the private seed industry are now ruling in many states like Maharashtra, Karnataka, Haryana, Punjab etc.

In addition, hybrids like Sun 496* (Sungrow seeds, Delhi), HOE 303*, Avinash 2* (Syngeta), BSS 20*, Meenakshi, Tolstoi (Beejo Sheetal), NA 501*, NA 601* (Nath Seeds), Sadabahar, Gulmohar, Sonali, MTH 6* (Mahyco, Jalna), ARTH 3*, ARTH 4* (Ankur Seeds), Rashmi, Vaishali, Rupali, Naveen (IAHS, Bangalore), Swaraksha, Uttam (Namdhari Seeds, Bangalore), Kt 4* (IARI, Katrain) etc. are a few hybrids popular among farmers.

Manure and Fertilizers

The fertilizer dose depends upon the fertility of soil and amount of organic manure applied to the crop. For a good yield, 15-20 tonnes of well-decomposed FYM is incorporated into the soil. Generally, application of 120 kg N, 80 kg P2O5 and 50 kg K2O per hectare is recommended for getting optimum yield. Half dose of N and full dose of P and K is given at the time of planting. The balance half of N is given as top dressing 30 days after transplanting.For hybrid varieties, the recommended dose per hectare is 180 kg N, 100 kg P2 O5 and 60 kg K2O. 60 kg N and half of P & K are given at the time of transplanting. Remaining quantities of P & K and 60 kg N is top dressed 30 after transplanting. A third dose of 60 kg N is applied 50 days after transplanting. Apply Neem cake 250 kg/ha ridges at the

time of preparing land. Dip the roots of seedlings (do not dip the foliage as it may cause burning of leaves) with imidacloprid 200 SL @ 0.3 ml/l or thiomethoxam 25 WP @ 0.3 g/l for 5 minutes.

Sowing time

Time of sowing is very important factor and in Northern plains only spring-summer crop is recommended for seed production. The sowing is done in middle of December.

Nursery raising and seed rate

Seeds @ 300-400 g/ha are sown on raised nursery beds of 60 cm width in rows at a distance of 2-3 cm. seedlings are protected against heavy rains and extreme weather conditions. Seedlings become ready for transplanting in 4-5 weeks time.

Transplanting of seedling in main field

When seedlings attain pencil thickness and 15 cm length they are ready for transplanting. The transplanting should be done in the evening on the sides of flat ridges of 60 cm width, followed by irrigation and normal

spacing is 60 x 45 cm. The ideal time for transplanting of spring-summer crop is 20th January to 10th February.

Irrigation

It is necessary to maintain even moisture supply, as overwatering is harmful. Water is essential at the time of flowering and fruiting. Adequate moisture also helps in better colour development during summer months. Irrigation is applied at 8-10 days interval in winter season where as during summer month; irrigation is applied at 4-5 days interval depending upon weather conditions.

Weed Management

Weeds are often a limiting factor in tomato production as they share light, water, nutrients and space, harbor insect pests and diseases. There are following techniques by which weeds can be managed very efficiently. These techniques are:

i) Soil solarization : Soil solarization in tomato crop is done by using 50-100 micron thickness polyethylene film. The cost incurred in purchasing polyethylene may be compensated by higher yield. This method also controls some soil born plant pathogens.

ii) Dead mulch: Crop residues like straws or stovers of rice, maize, sorghum, mustard or wheat can be used as a dead mulch if they are available or left as a waste.

iii) Frequent weeding: Hand weeding at least four all through the growing period of tomato due to continuous germination of weed seeds. Hand weeding at initial stages may be replaced by chemical weeding and later it may be supplemented with chemical weeding. Chemical weeding may reduce the cost of weeding in tomato.

iv) Earthing up: Earthing up is done when the tomato become aged about 35 to 40 days in transplanted field. It may be good practice to reduce the weed population in tomato field.

v) Chemical control

Name of herbicides	Doses (a.i. kg/ha)	PPI/PRE/POE	Control weeds
Trifluralin	0.75-1.0	PPI	Annual grass and some BLWs
Alachlor	1.0-2.0	PRE	Annual grass and some BLWs
Diclofop-methyl	1.0	PPI /PRE	Annual grass
Metalochlor	0.72	PRE	Annual grass and some BLWs
Metribuzin	0.5	PPI/early POE	Broad spectrum weed control
Chlorthal-dimethyl	1.5-2.0	POE	Annual grass and some BLWs

PPI (Pre Plant Incorporation), PRE (Pre-Emergence), POE (Post-Emergence), BLW(Broad Leaves Weeds)

Staking

Staking is an important operation for tomato. Staking should be done 20-25 days after transplanting. The plants should be loosely tide on horizontal stakes. The timely staked plants produce more and better quality fruits.

Rouging

Plants showing different characters to the type must be removed. Roguing is done at different stages of crop growth.

- ❖ Before flowering-Plants showing different growth habit and foliage characteristics than the particular variety should be rogued out.
- ❖ Early flowering and fruit setting stage-Off-types are rogued out judging the size and shape of immature fruits.
- ❖ Fruiting stage-The off-types are identified examining the fruit characteristics like shape, size, colour etc.

Under Indian seed Act following field standards and seed standards are fixed for tomato seed production.

Specific Requirement (Field standards)

Factors	Maximum permitted %	
	Foundation seed	**Certified seed**
Off type	0.10	0.50
*Seed born diseases	0.10	0.50

*Early blight, Leaf spot and Mosaic (TMV)

Field inspection: Number and stages of field inspection for certifications are:

i) Before flowering

ii) Full flowering/ immature fruit stage

iii) Mature fruit stage

Seed standards

Factors	Class of seed	
	Foundation seed	**Certified seed**
Pure seed (minimum)	98.00	97.00
Inert matter	2.00	2.00
Other crop seed (Maximum)	0.05	0.10
Weed seeds	None	None
Germination % (Minimum)	70.00	70.00
Moisture content % (Maximum)	8.0	8.0

Plant Protection

(A). Insect-pests

Tomato fruit worm (Borer): Moths are brown to yellowish brown in colour. Caterpillars are green in colour, they attack during October-March. They rollover the leaves and find its way to the fruits where it cut holes. Egg masses on affected fruits are collected and destroyed. In case of severs infestation spray 0.2% Carbaryl or Thiodan 1 ml/ litre of water. Spraying should be repeated at fortnight intervals.

Whitefly: They are minute insects of white colour and suck the sap of plant. It transmits leaf curl disease. Affected leaves get shriveled and gradually curl up. Spraying 0.025% Rogor in the early stage of crop growth can control whitefly and jessids.

Root knot nematode: Three species, *Meloidogyne incognita*, *Meloidogyne arenaria* and *Meloidogyne japanica* are common in tomato. Symptom consists of foliage discoloration to pale then normal unthrifty development, dwarf and wilting. Insects can be controlled by use of resistant varieties namely Pusa 120, Nematex, Anahu, Atkinson, VNF-8. Use of dichloropropane mixture (DD) is recommended.

(B). Major diseases

Tomato crop is affected by many diseases. Some of the most important diseases, which are found in India, are presented below.

Damping off: A very destructive disease in nursery beds especially during rainy season. The seedlings are attacked at ground lavel and as a result they topple over. Seed treatment with Thiram or Captan @ 3g/kg of seed. Sow nursery in a raised bed with proper drainage. Drench

the nursery bed with Captaf or Bavistin @ 2 g of fungicide per litre of water at 10-15 days interval.

Leaf Curl virus: This disease is more severe in monsoon crop. It is characterized by curling of leaves, reduction in leaf size, excessive branching and stunted plant growth. The virus spreads through a vector, white fly (*Bemisia tabaci*). The disease can be checked by control of vectors whitefly by spraying the crop with Rogor or Thiodan at fortnight interval.

Early blight: This disease is caused by *Alternaria solani*. The fungus is soil-borne. Circular, angular, dark brown spots appear on leaves, stem and fruits. Concentric circles of 2-5 mm in diameter are formed at advanced stage. Fruits are also affected showing sunken large dark brown leathery spots on green fruits. Spray of Dithance Z-78 @ 2 g / litre of water is helpful in controlling the disease.

Bacterial wilt: It is a most serious disease of tropical and temperate regions. Lower leaves may drop before wilting; plants are stunted with yellow leaves. Pith of root is dark brown to black in colour and water soaked. Use of resistant varieties, crop rotation and application of oil cakes, neem cakes are time tested measures for controlling the disease.

Harvesting and Seed Yield

For seed production fruits are harvested at fully ripe red colour stages. Seed fruits are allowed to ripen to maturity on the plant. Only completely colored and matured seed fruits are harvested. The mark of the two sepals (calyx) cut off should be checked carefully to ensure that only pollinated fruits are harvested. Around 250-400 kg/ha seed is produced depending on the plant type/ variety.

Stages of maturation: Mature green, Breaker, Turning, Pink, Red, Dark red / over ripe

The fruits from in between 6-7 harvest should be used for seed extraction. The seed viability is depends on the method on which the seeds were extracted and hence, it is more important to choose proper methods of seed extraction. Before seed extraction, the fruits are to be graded for true to type and selection of medium to large size fruits for getting higher recovery of quality seeds.

Seed Extraction

The following methods have been suggested by many workers for tomato seed extraction.

1. Fermentation Method

In this method the selected ripe fruits are harvested and kept in wooden or plastic containers for two to three days until the fruits become soft. They are crushed by hand and no fruit juice is allowed to drain out. Entire mass is kept for 24 to 72 hours depending upon temperature. Flesh will float at the top and seed will settle down at the bottom. The fermented mass is removed and the seeds are sieved and cleaned with fresh clean water and dried. Longer fermentation may damage the seed.

2. Separation with Sodium Carbonate

This method is relatively safe and can be used for small quantities of seed in cooler temperate areas where the fermentation method is not used. The pulp containing the extracted seeds are mixed with equal volume of a 10 per cent solution of sodium carbonate (washing soda). The mixture is left up to two days at room temperature after which time the seed is washed out in a sieve and subsequently dried. The sodium carbonate method of extraction tends to darken the testa of the seed and is, therefore, not normally used for commercial seed.

3. Separation with Hydrochloric Acid

This method is often favoured by large commercial producers as it produces a very bright clean seed sample. The hydrochloric acid treatment is often combined with later stages of fermentation. It was reported that 50 ml of concentrated hydrochloric acid stirred into 10 litres of seed and pulp mixture and left for half an hour is successful. After the extraction seeds must be dried as quickly as possible. A common method as described by Webster (1944) is to spread the seed in screen-bottom trays which are placed on racks out of doors so that the air passes both above and below full effect of the solar energy. Occasional stirring of the seed speeds the drying process. Drying of tomato seed is done up to the moisture content of 8%.

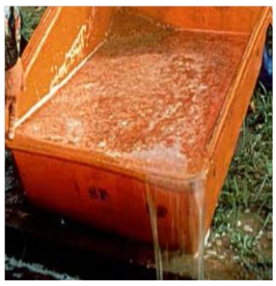
The acid method of seed extraction is the best method for tomato seed extraction. In this method, the fruits are to be crushed into pulp and taken in a plastic containers (or) cement tank. And then add 30 ml of commercial Hydrochloric acid per kg of pulp, stir well and allow it for ½ hour. In between this duration the pulp may be stirred well for one or two times. This facilitates the separation of seed and pulp. After ½ hour, the seeds will settle down at the bottom and then the floating fraction is to be removed. The collected seeds should be washed with water for three or four times.

- While following acid method we must use only plastic or stainless steel containers or cement tank.
- Care must be taken to avoid the usage of iron or zinc containers, which will affect the viability potential of the seeds and as well damage to the containers due to chemical reaction with acid.
- For large scale seed extraction we can use the tomato seed extractor developed by Tamil Nadu Agricultural University.
- The seeds extracted by this machine may again be treated with commercial Hydrochloric acid @ 2-3 ml/kg seed with equal volume of water for 3-5 minutes with constant stirring. And then seed should be washed with water for to four times.
- It is easy to dry the seeds extracted by acid method and also remove the fungus growth over the seed coat, thus seeds possess golden yellow colour and high vigour.
- The seed extracted by fermentation method posses poor vigour and off colour due to fungal activity

1. Fermentation method

			
Manual Crushing	Fermentation	Washing	Extracted seed

2. Acid seed extraction method

			
Mechanical Crushing	Extracted seed	Acid treatment	Washing of seeds

Drying and grading

Seeds are to be dried in the shade. It should never be dried in hot sun. the safe moisture content of the seed for grading is 8 to 9 per cent. Seeds can be graded using 6/64'' round perforated sieve.

Storage

The seeds dried to safe moisture content after treating either with captan or thiram @ 2 g/kg can be stored for 15 months in moisture vapour pervious containers, while it can be stored in moisture vapour proof containers for 30 months.

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