

Hybrid Seed Production in Tomato

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Introduction

Hybrid tomato varieties have many advantages compared to open-pollinated varieties. Hybrids usually produce higher yields. They generally mature earlier and more uniformly. Many hybrids have better fruit quality and disease resistance. With all of these advantages, many farmers prefer to sow hybrid seeds in spite of the higher seed costs.

The demand for hybrid tomato seeds can open a new market for growers interested in seed production.

Hybrid tomato seed production is not easy. First, it requires much labor (see page 5). Fortunately, this is not a problem in developing countries where affordable labor is available. Second, it requires the mastery of special skills and a close attention to detail. This publication will teach these skills.

Crop Management

Climate

Ideal growing conditions are needed to produce high quality seed. Tomatoes grow best in the dry season under day temperatures of 21-25°C and night temperatures of 15-20°C. Vines will struggle to set fruit if temperatures exceed 30°C.

Humidity is an important factor. Humidity levels higher than 60% at the time of fruit maturity will



Figure 1. *Producing hybrid tomato seed requires special skills. In this photo, a seed producer is carefully preparing a flower for hybridization.*

increase disease problems and reduce seed yields. Seed production during the rainy season generally leads to low yields and poor seed quality.

Field Requirements

Avoid planting your tomato seed crop in a field previously planted with tomato, pepper, eggplant or other solanaceous crops. This will prevent the build-up of diseases and insects. Growing tomato after paddy rice reduces the incidence of diseases and nematodes.

Optimum soil pH for tomato is 6.0 to 7.0; disorders such as blossom end rot are common if soil pH is lower than 5.5.

Cultural Practices

Healthy plants produce healthy seeds. Pests should be controlled. Nutrient and water management should be optimal to achieve good fruit and seed yield. For more information on growing tomato, see AVRDC International Cooperators' Guide, *Suggested Cultural Practices for Tomato*.

Selecting Parents

Hybrid seed production involves the crossing of a female line to a male line. Either line can be the female or male parent, but normally the best seed yielder is selected as the female parent. Both parents should be pure, preferably being self-pollinated for more than six generations (this is called *inbreeding*). The inbred parents are selected for their desirable traits (e.g., high yields, disease resistance, fruit quality, earliness, etc.).

Ratio of Male to Female Plants

It is important to have plenty of pollen available for making hybrid crosses. Since tomato vines bloom profusely, a ratio of one male for every four female plants is recommended.

Sowing Dates

Seeds of male plants are sown three weeks earlier to ensure that pollen is available from the beginning of hybridization.

Isolation

Each tomato flower has both male and female parts (see Figure 3 on next page). Nearly all lines, including modern varieties, are *self-pollinating*. In other words, the pollen from each flower's stamens pollinate only the style of the *same flower*. Isolation of male and female parental lines is not necessary. Male plants can be planted as close as two meters from female plants.

There are a few exceptions. Currant tomatoes (*L. pimpinellifolium*) and potato-leaf types of *L. esculentum* generally have styles that protrude outside their blossom. These lines are more attractive to insects and thus, more likely to be cross-pollinated. Netting or caging to exclude pollinating insects is required if any of these types are used as female lines. Also, do not collect seeds of double fruits since double flowers are more prone to insect pollination.

Plant Location and Spacings

Male lines are planted in a different location to facilitate operations and avoid shading from competing plants. Select a sunny spot to promote maximum production of flowers and pollen.

Male and female lines are planted in double-row raised beds, with centers of beds spaced 150 cm apart. For female lines, plants are spaced 50 cm apart within the row (Figure 2). Male plants are spaced 40 cm apart to maximize flower production per hectare.

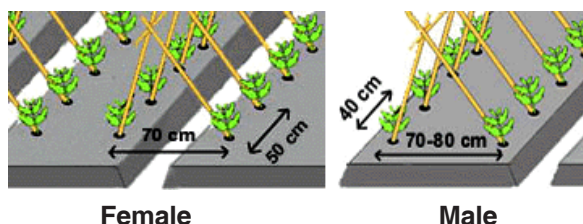


Figure 2. Spacing and staking options for female and male lines.

Staking

The female parent is staked. Staking facilitates the handling of plants during emasculation and pollination. Staking also keeps the ripening fruits above the ground and prevents rotting. Plants are trellised along with plants from the adjoining bed so that work operations are done on the raised bed rather than in the furrow.

Among male lines, only indeterminate types need to be staked. If male lines are staked, trellising can be done within beds (as shown for male lines in Figure 2) or across adjoining beds (as shown for female lines in Figure 2).

Removing Off-Types

The male and female lines must be 100% pure. Know the plant habit, leaf type, and immature fruit characters (e.g., shape, size, and shoulder coloring) of each parent. Regularly inspect the plants.

Remove any off-type (usually inferior) or virus-infected plants before hybridization procedures begin. Symptoms of viruses include yellow mottling of leaves; severe curling, cupping or other distortion of foliage; and stunting of plants.

Emasculation

Overview

Self-pollination cannot be allowed in hybrid seed production. The female flower must be pollinated by the pollen from the male line.

To prevent self-pollination, remove the stamens from the flower buds of the female line before they shed their pollen (Figure 3). This process is called *emasculation*.

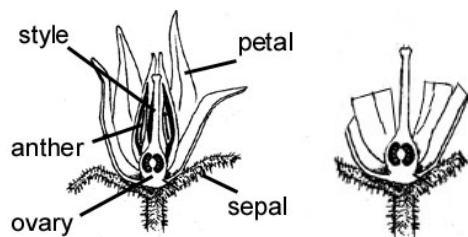


Figure 3. *Tomato flower before and after emasculation. The anther and surrounding cap are removed to prevent self-pollination. The petals and sepals are cut to identify the flower for future pollination.*

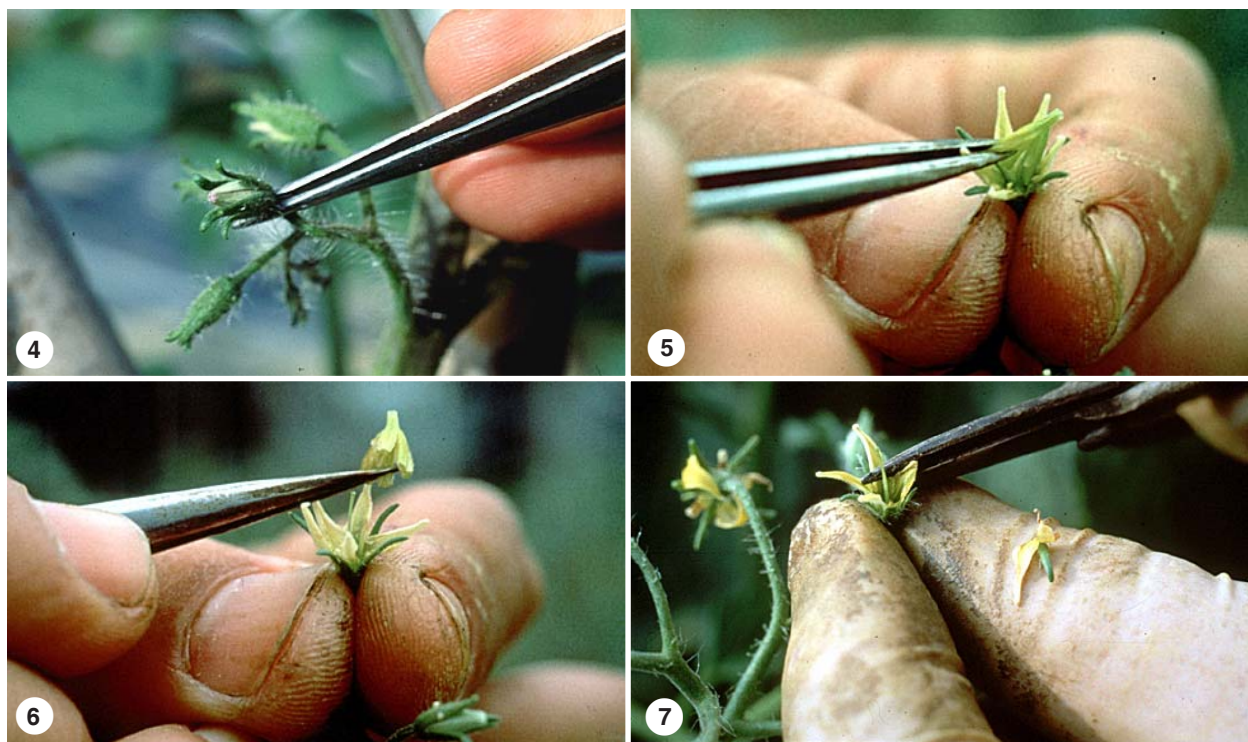
Procedure

Emasculation begins about 55-65 days after sowing. Flower buds from the second cluster which will open in two to three days are chosen for emasculation (Figure 4). The petals will be slightly out of the flower bud but not opened, and the corolla color is slightly yellow or even paler. Flowers from the first cluster are removed.

Sterilize the forceps, scissors and hands by dipping them in 95% alcohol before emasculation is started. If gloves are used, these should also be dipped in 95% alcohol to prevent pollen contamination.

Use sharp-pointed forceps to force open the selected buds. Then, split open the anther cone (Figure 5). Carefully pull the anther cone out of the bud, leaving the calyx, corolla and pistil (Figure 6).

To help identify the hybrid fruits from selfed fruits at the time of harvest, cut the corolla and calyx (all or two sepals) (Figure 7).



Figures 4-7. *Emasculation of tomato: selection of buds, removal of anther cone, and cutting of petals.*

Pollen Collection

Collect flowers from the male parent to extract pollen (Figure 8). The best time for pollen collection is during the early morning before the pollen has been shed. Avoid pollen collection on rainy days.

Remove the anther cones from the flowers and put them in suitable containers, such as glassine, cellophane, or paper bags (Figure 9).

Dry the anther cones by placing them 30 cm below a 100-watt lamp for 24 hours (Figure 10). The lamp creates a drying temperature of about 30°C. Pollen can also be sun-dried, but avoid drying at midday when temperature is very high.

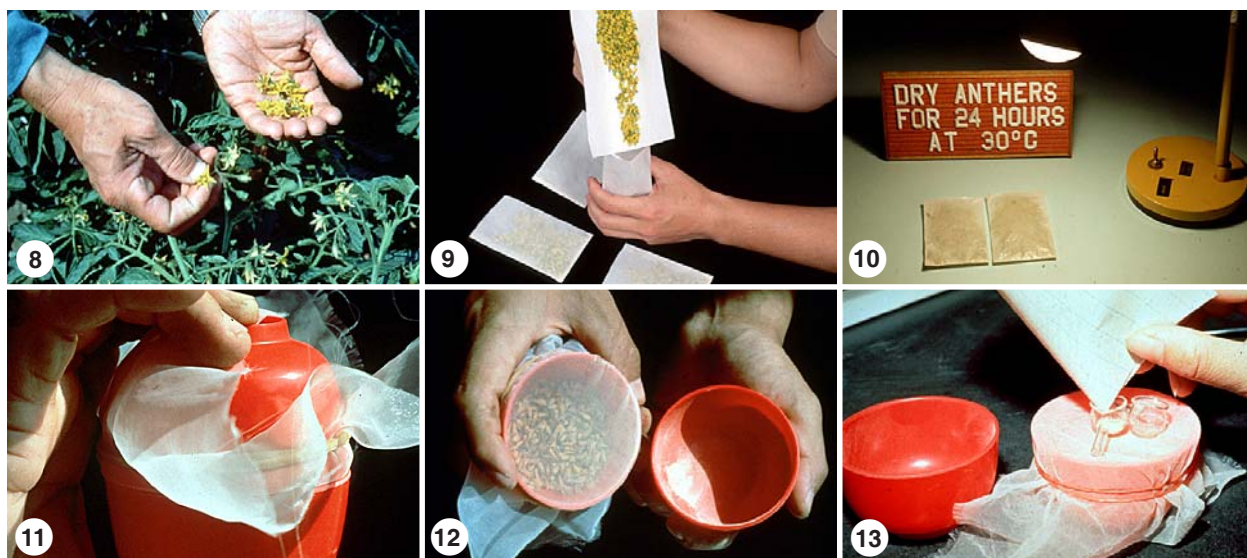
Put the dried anther cones in a plastic pan or cup. Cover the cup with a fine mesh screen (200-300 mesh) and then seal it with a similar tight-fitting cup, serving as a lid (Figure 11).

Shake the cup about 10-20 times so that the pollen is collected in the "lid" cup (Figure 12). Transfer the pollen into a small convenient-to-handle container for pollination (Figure 13).

Fresh pollen is best for good fruit-set. It can be kept for one day at moderate room temperature.

When weather conditions are not suitable for pollination, dried or dehydrated pollen can be stored in a sealed container (capsule or vial) and kept in the freezer for about a month. Without freezing, the pollen can be kept in an ordinary refrigerator for two to three days without any significant loss in viability.

The pollen should be taken from the freezer or refrigerator and kept closed until the container warms to room temperature. This will prevent the pollen from getting wet due to condensation.



Figures 8-13. Pollen is collected, dried, and prepared for making hybrid crosses.

Pollination

Emasculated flowers are generally pollinated two days later. Try to avoid pollination on rainy days. The corolla of the emasculated flower turns bright yellow, signalling that the stigma is ready for pollination (Figure 14).

Dip the stigma into the pool of pollen in the pollen container (Figure 15) or pollinate by touching the stigma with the tip of the index finger dipped in the pollen pool (Figure 16).

Pollination is usually done three times weekly over a three to five week period. Successful pollinations are easily seen within one week by the enlargement of the fruit.

Labor Demands for Hybrid Seed Production

Emasculation and pollination are very labor intensive! About 0.1 ha of indeterminate female plants requires two to three persons for five to six weeks. The same area of determinate female plants requires four to six people for three weeks.

After breeding operations are completed, any non-crossed flowers on the female plants are removed to lessen the chance of contamination from selfed seeds before harvest.



Figures 14-16. Pollination of emasculated flowers.

Fruit Production

The number of hybrid fruits produced per plant depends on the fruit size of the maternal parent. As a rule of thumb, maintain the following: 30 fruits for large-fruited parent; 40 fruits for medium-fruited parent; and 50 or more fruits for small-fruited parent.

Hybrid fruits are easily recognized by their cut sepals (Figure 17).

Remove the naturally-pollinated (non-hybrid) fruits, if any, from the female plants. This removal will prevent the accidental mixture of non-hybrid with hybrid fruits. Furthermore, non-hybrid fruits will steal nutrition away from the ripening hybrid fruits.



Figure 17. Ripening seed crop. Note that a few sepals on each fruit have been cut to indicate the fruit contains hybrid seed. Non-hybrid fruits have been removed.

Harvesting

Tomato fruits ripen about 50-60 days after pollination, but may take longer if temperatures are cool.

Keep the fruits on the vine until they are fully mature, preferably to the pink or red ripe stage. This enables the seed to develop normally and fully. If fruits are harvested at an earlier stage, place them in a covered, cool dry place for three or four days until they become red ripe.

Be sure to check for the clipped sepal before harvesting fruit.

Collect fruits in nonmetallic containers, such as nylon net bags, plastic buckets, or crates. Metal containers may react with acids in the tomato juice and affect seed viability. Hence, they should not be used.



Figure 18.
Harvesting

Seed Extraction

Option 1: Manual Extraction

Harvest the ripe fruits and keep them in nylon bags (Figure 19). Crush the fruits by trampling with feet (Figure 20).

Put the bags of crushed fruits into big plastic containers and ferment to separate the gel mass embedding the seeds. To hasten the fermentation process, put weights over the bags or keep the fruits submerged in the liquid fruit mass (Figure 21).

The time of fermentation depends upon the ambient room temperature. If temperature is above 25°C, one day of fermentation may be sufficient. If cooler, two days of fermentation may be needed. Fermentation for more than three days may spoil the seeds' quality.

To wash the seeds, put them in an open plastic container. Then fill the container with water and stir the seeds to allow the pieces of flesh and skin sticking on the seeds to float.



Figures 19-24. Tomatoes are harvested in bags. The fruit are crushed and then fermented. Seeds are washed by careful removal of floating pieces of flesh and skin.

Incline the container and gently remove the floating refuse, making sure that the seeds remain at the bottom (Figures 22 and 23). Repeat the washing several times, adding fresh water to the container every time until all the flesh and gel are completely removed, leaving clean seeds at the bottom (Figure 24).

Option 2: Mechanical Extraction

Mechanical seed extraction is used by large-scale operations. Put ripe fruits into a mechanical seed extractor for crushing and separation of the seeds and gel from the pulp (Figure 25).

Gather the seeds and gel mass in a suitable container such as plastic tub or bucket (Figure 26).

Instead of fermentation, treat the seed-gel mass with 0.7% hydrochloric acid (HCl) at a rate of seven milliliters of HCl per kilogram of seed-gel mass (Figure 27). Stir the seed-gel mass while the acid is being added. Continue stirring for 40 minutes until the gel is visibly softened or dissolved. Do not use a higher concentration of acid

nor a longer treatment time, otherwise you will injure the seeds.

When the seed is separated from the gel, pour the acid-treated seeds into a clean fine-mesh bag. Wash the bag with tap water thoroughly so that no acid is left on the seeds' surface (Figure 28). While washing, step on the bag to squeeze out the remaining gel.

Place the seeds into a plastic container, filling it to one-third capacity. Then, fill up the container with tap water. Stir the seeds to enable the small pieces of flesh and skin to float. Incline the container and remove the floating debris (Figure 29). Make sure the seeds remain at the bottom of the container.

Repeat the washing procedure several times until all the debris is gone and the seeds are clean.



Figures 25-29. A machine is used to extract seeds from fruits. Seeds are then treated with hydrochloric acid to loosen their gelatinous coating, and then cleaned using water.

Seed Drying

Place the washed seeds in bags. Excess water can be removed by hanging the seeds in the shade for a day. An even quicker way to remove water is to place the seeds in a spin dryer (Figure 30).

After the excess water is removed, uniformly spread the partially dried seeds in a flat plastic container or aluminum pan. Loosen any clumps of seeds (Figure 31). Enclose this container with its seeds into a net nylon bag.

Place the container into an air drier (Figure 32). Drying continues for three to four days, maintaining a temperature of 28-30°C. Higher temperatures at the time of drying may cause seeds to germinate.

Stir the seeds two to three times daily so that seeds dry uniformly. Loosen any seeds that clump together. These procedures will get the seeds to the desired 6-8% moisture content.

Seed Packaging and Storage

Pack and deliver the dried seeds according to specifications of the seed company or contract agency.

If necessary, tomato seeds can be safely stored for at least three to five years. Place seeds in manila envelopes, cloth or mesh bags, plastic containers, or foil envelopes. The best containers are airtight, such as a sealed glass jar, metal can, or foil envelope.

Label each container carefully. Note the names of the hybrid and parents, the date, and any other information you feel is valuable.

Store seeds in a cool, dry place. Small quantities can be kept in an airtight container inside a refrigerator. For larger quantities, a special room with controlled humidity and temperature should be used. If possible, the temperatures should not exceed 20°C and relative humidity (RH) in the storage area should not exceed 30%.



Figure 33. Seed storage room

More Information

For more information on hybrid tomato seed production, contact Dr. Peter Hanson at <hansp@avrdc.org>.

A slide set on this topic is available. In addition, International Cooperators' Guides have been written on numerous topics related to tomato cultivation and vegetable seed production. This includes a guide that describes the production of open-pollinated tomato seed. All of this information is available at the AVRDC web site, <<http://www.avrdc.org>>.



Figures 30-32. Seeds are spun-dried, spread and loosened in a flat container, then rebagged and placed into an air drier.