

Blossom Drop, Reduced Fruit Set, and Post-Pollination Disorders in Tomato¹

Monica Ozores-Hampton, Fnu Kiran, and Gene McAvoy²

Blossom drop and reduced fruit set in tomato can seriously impact yields. Growers in Florida routinely experience such problems and inquire about the cause and possible preventative measures to reduce flower loss and improve yields. The problem can be frustrating and difficult to manage in some situations.

Tomato flowers are complete flowers in that they have both male (stamens) and female (pistil) parts within the same flower (Figure 1). The yellow stamens wrap around the greenish pistil in the center of the flower (Mills 1988). The

stamen has two parts: filament and anther, and the pistil has three parts: ovary, style, and stigma (Figure 2). The style is the long stalk that reaches up to the bumpy, sticky stigma, which extends beyond the surrounding stamens. Tomatoes are self-pollinated at the rate of 98% or more. Pollination occurs primarily between 10 a.m. and 4 p.m. (Levy, Rabinowitch, and Kedar 1978). Tomatoes need biotic or abiotic agents to assist in pollination.



Figure 1. Reproductive features of tomato flower. Left: female pistil. Center: open tomato flower. Right: male stamens.
 Credits: Monica Ozores-Hampton

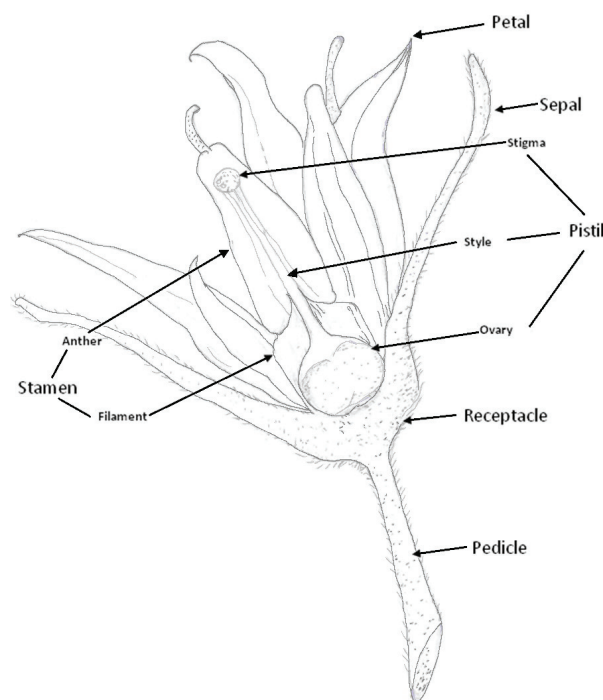


Figure 2. Tomato flower structure
 Credits: Carlos Ozores

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2. Monica Ozores-Hampton, assistant professor, and Fnu Kiran, biological scientist, Horticultural Sciences Department, UF/IFAS Southwest Florida Research and Education Center, Immokalee, FL 34142; and Gene McAvoy, county Extension director and regional vegetable extension agent, UF/IFAS Hendry County Extension Service, LaBelle, FL 33975.

In *open-field production*, pollination is accomplished by wind. Tomato flowers hang down (Figure 3), and anthers are located above the stigma. The pollen is released and falls downward onto the stigma. Insect pollinators are not important for pollination of tomatoes grown in open-field production (Levy, Rabinowitch, and Kedar 1978; Ozores-Hampton and McAvoy 2010).

In *greenhouse production*, where plants are protected from the wind, growers used to mechanically shake individual flower trusses or entire plants to stimulate the release of pollen. However, the predominant means of accomplishing pollination now is through the use of bumble bees. The bumble bee sonicates for pollination, meaning it vibrates its wing muscles without flight. This causes the whole flower to vibrate, and a cloud of pollen is released onto the bee's body and onto the stigma at the same time.



Figure 3. Open tomato blossoms hanging downward direct the pollen from the anthers to the stigma.
Credits: Monica Ozores-Hampton

Blossom drop is defined as the loss of flowers (Figure 4). Several factors, usually related to some type of stress, can cause tomato plants to drop their blooms. The stress may be either nutritional, environmental, or a combination of the two. However, anything that interferes with the pollination and fertilization processes may result in flower loss (Levy, Rabinowitch, and Kedar 1978; Mills 1988; Ozores-Hampton and McAvoy 2010). Without pollination, which stimulates fruit set, the flowers die and drop. This condition can affect tomatoes, peppers, snap beans, and other fruiting vegetables. In tomatoes, blossom drop is usually preceded by the yellowing of the pedicle. Tomato flowers must be pollinated within approximately 50 hours or they will abort and drop off. This is about the time it takes for the pollen to germinate and travel up the style to fertilize the ovary at temperatures above 55°F.



Figure 4. Blossom drop on tomatoes, January 2010, Immokalee, FL
Credits: Monica Ozores-Hampton

Potential Causes of Blossom Drop

The primary causes of blossom drop in tomatoes are environmental (e.g., temperature and relative humidity [RH]) or cultural (e.g., lack or excess of nitrogen [N] fertility). Secondary causes can include lack of water, reduced or extended light exposure, excessive wind, insect damage, foliar disease, excessive pruning, or heavy fruit set.

Primary causes of blossom drop

Temperature: Tomato plants drop their flowers under extreme temperature regimes, such as high daytime temperatures (above 85°F), high nighttime temperatures (above 70°F), or low nighttime temperatures (below 55°F) (Table 1). Optimal growing conditions for tomatoes are daytime temperatures between 70°F and 85°F. While tomato plants can tolerate more extreme temperatures for short periods, several days or nights with temperatures outside the optimal range will cause the plant to abort flowers and fruit and focus on survival (Mills 1988). Temperatures over 104°F for only 4 hours can cause the flowers to abort. If nighttime temperatures fall below 55°F or rise above 70°F, or if daytime temperatures rise above 85°F, the pollen becomes tacky and nonviable, preventing pollination from occurring and causing the blossom to dry and drop (Chester 2004; Levy, Rabinowitch, and Kedar 1978; Mills 1988; Ozores-Hampton and McAvoy 2010).

Low temperature: Low temperatures interfere with the growth of pollen tubes, preventing normal fertilization. The pollen may even become sterile, which causes blossoms to drop. Tomato fruit do not set until nighttime temperatures are above 55°F for at least two consecutive nights (Chester 2004; Ozores-Hampton and McAvoy 2010).

High temperature: Sustained high temperatures, especially at night, rapidly deplete the food reserves that are produced in the tomato during the day. The result is sticky pollen,

altered viability, and poor or no pollination. Ultimately, the blossom dries and falls off. Female flower parts can also undergo morphological changes, such as drying of the stigma (Mills 1988; Ozores-Hampton and McAvoy 2010).

Relative humidity: The ideal RH for tomato growth and development ranges between 40% and 70%. Relative humidity plays a major role in pollen transfer. If RH is lower than the optimal range, it interferes with pollen release because the pollen is dry and unable to stick to the stigma. If RH is higher than the optimal range, the pollen will not shed properly (Mills 1988; Ozores-Hampton and McAvoy 2010).

Nitrogen: High or low application rates of N fertilizer can cause blossom drop. High rates of N encourage the plant to produce excessive vegetation at the expense of fruit set. Low N produces spindly vines with low food reserves that cannot support a tomato crop (Chester 2004; Levy, Rabinowitch, and Kedar 1978; Mills 1988; Ozores-Hampton and McAvoy 2010).

Secondary potential causes of blossom drop

Low or high soil moisture: Tomatoes have deep roots that can penetrate up to 5 feet. Low soil moisture stresses and weakens the plants. The root zone should be kept uniformly moist throughout the growing season to develop a large root system and reduce plant stress (Chester 2004; Ozores-Hampton and McAvoy 2010).

Heavy fruit set: When a tomato plant has produced a large number of blossoms, the resulting fruits compete for the limited food supplied by the plant. The plant will automatically abort some flowers. Once the initial crop is harvested, the problem should subside as the plant's nutritional status comes back into balance (Levy, Rabinowitch, and Kedar 1978; Mills 1988; Ozores-Hampton and McAvoy 2010).

Wind/pruning: Excessive wind can desiccate flowers and/or physically knock them off, reducing fruit set. Excessive pruning can reduce the amount of energy the plant produces and thus can reduce flower production and fruit set.

Light: Lack of sufficient light or extended exposure to light can reduce fruit set.

Insect damage or disease: Growers should use adequate cultural practices to control insects and diseases. Fungal diseases—such as botrytis, heavy bacterial spot, or bacterial speck pressure—have a negative effect on fruit set.

Hormones and Tomato Fruit Set

Hormones are natural organic compounds produced by the plant, which regulate responses, such as bud development, root growth, and fruit setting. Hormones can also be produced artificially and applied to regulate plant growth. Hormone treatments can be effective during periods of low nighttime temperatures, but the resulting fruit may be seedless, of poor quality, and suffer from puffiness and blossom-end scar (Minges and Mann 1949). However, favorable results were obtained when hormones were applied with hand sprayers directly on the flowers rather than to the whole plant (Chen and Henson 2001). Whole-plant application can result in plant injury. Hormone treatments do not increase total marketable yields of tomatoes but can shift a portion of the yield to earlier in the season (by increasing fruit size). Normally, one application at flowering and another application 15 days later produce improved flower and fruit set (Chen and Henson 2001). There are many hormones and nutritional products commercially available that may increase tomato blossom and fruit set, but generally these products do not produce consistent results. Currently, the UF/SWFREC Vegetable Program is testing commercially available products that may have an effect on tomato and pepper flower and fruit set in growth chambers under high and low temperatures and RH.

How to Control Tomato Blossom Drop

1. Grow varieties suited to the climate, such as varieties with greater heat-setting ability
2. Use recommended N rates
3. Water deeply during dry weather
4. Control insects and diseases

Under high temperatures and low RH conditions: Under controlled production situations (greenhouses), direct a gentle spray of water at the blossoms twice during a hot day to improve flower set when daytime temperatures range between 90°F and 100°F and below 75°F at night. The evaporating moisture lowers the temperature, raises the humidity, and jars the pollen loose, thereby improving flower set. If daytime temperatures exceed 100°F and nighttime temperatures exceed 75°F, this technique is not effective.

Under high temperatures and high RH conditions: Watering the foliage is not recommended, especially when fungal diseases are present.

Post-Pollination Disorders

Catface: This condition involves malformation and scarring of fruits, particularly at blossom ends. Affected fruits are puckered with swollen protuberances and can have cavities extending deep into the flesh (Zitter and Reiners 2004).

Causes: Possible causes include extreme heat, cold weather with nighttime temperatures 58°F or below at flowering, drought, high N levels, or herbicide injury spray. Tomato varieties with very large fruits are more susceptible (Olson 2009).

Control: Avoid setting transplants too early in the season, grow catface-resistant varieties, and avoid herbicide injury.

Zippering: This condition is characterized by the presence of brown tissue (resembling a zipper), usually running from the stem end to the blossom end and caused by abnormalities during early flower development (Cox, Tilth, and Coolong 2011; Zitter and Reiners 2004).

Causes: This condition is the result of an anther remaining attached to newly forming fruit. It is also associated with incomplete shedding of flower petals when the fruit is forming. It may sometimes be attributed to high humidity. In cooler weather, parts of the flower may adhere to the developing fruit and result in zippering (Olson 2009).

Control: Select varieties that are not prone to zippering.

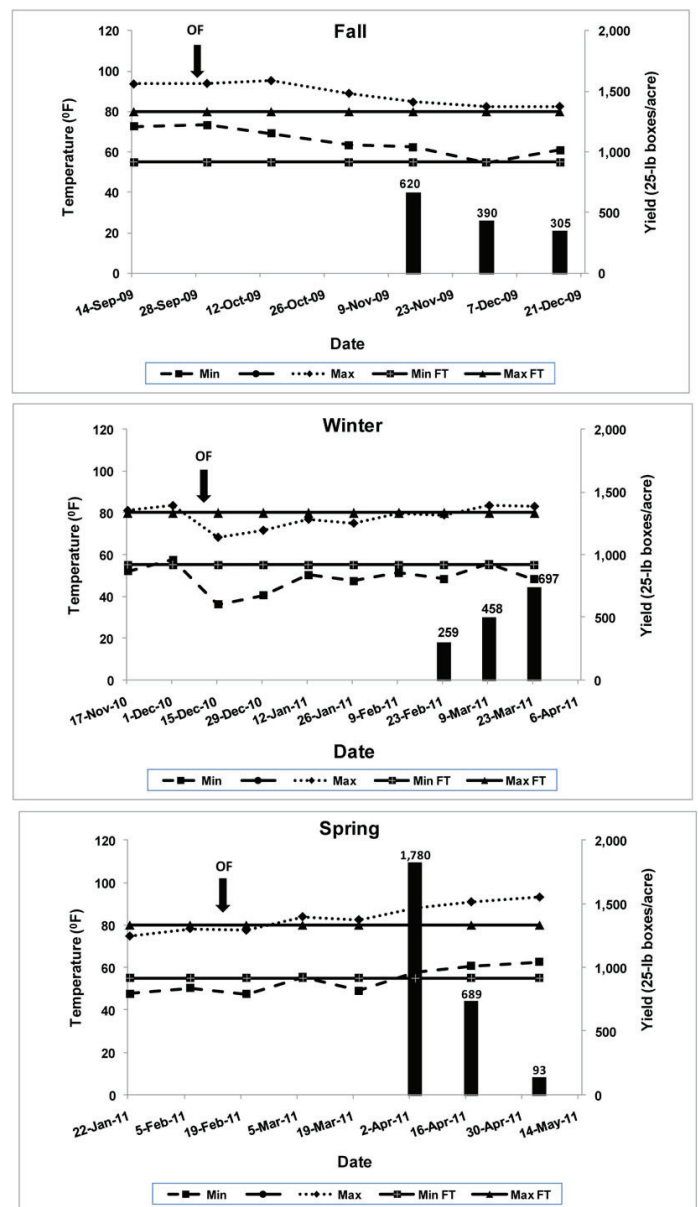
Puffiness: This condition is characterized by fruit that appear bloated, flat sided, or angular, leading to oddly shaped fruit. The locular gel (the liquid that surrounds the seeds) fails to fill the fruit's inner cavity, resulting in a fruit with flattened sides that lacks firmness (Cox, Tilth, and Coolong 2011; Olson 2009).

Causes: This condition can be caused by incomplete fertilization or seed development due to cool temperatures or, under greenhouse production, by the lack of vibration or shaking, which assists in releasing the blossoms' pollen. Other factors, such as low light or rainy conditions, high N or low potassium, may also contribute to puffiness.

Control: Ensure adequate growing conditions and plant nutrition.

In South Florida, tomatoes are planted continuously between August and February. Tomato growing seasons are typically defined as fall, winter, and spring, with planting dates between 15 Aug. and 15 Oct., 16 Oct. and 15 Dec., and 16 Dec. and 15 Feb., respectively (Ozores-Hampton

et al. 2006). Based on planting season, the length of the growing season averages 18, 20, and 16 weeks for fall, winter, and spring, respectively. Historical temperatures (average \pm standard deviation in °F) from a weather station located in Immokalee, FL, are 79.6 \pm 1.5, 69.0 \pm 4.4, and 67.4 \pm 6.2 for fall, winter, and spring, respectively. Hence, restrictions in marketable tomato yields in the fall planting season are primarily due to temperatures above 85°F during the day and 70°F during the night together with high rainfall and RH (Figure 5a). During the winter, temperatures below 55°F during the night often lower marketable tomato yields (Figure 5b). In the spring season,



* FT = Flower Temperature, OF = Open Flower
Weather data was obtained from Florida Automated Weather Network (FAWN) from University of Florida/IFAS, Southwest Florida Research and Education Center in Immokalee, FL.

Figure 5. Overview of fall, winter, and spring minimum and maximum temperatures and tomato marketable yields in Immokalee, FL
Credits: Monica Ozores-Hampton

high marketable tomato yields are due to ideal temperatures during the day and night (70°F and 85°F) (Figure 5c).

In Southwest Florida, tomato variety recommendations are normally based on disease resistance packages, especially with regard to resistance to soil pathogens prevalent in the area. Perhaps breeding for heat or cold tolerance or high RH (i.e., hot and wet in the fall and cold and dry in the winter) is not the primary selection factor a breeder or grower considers, but the breeding is still towards yield under Florida conditions. Table 2 shows two variety recommendation programs for Southwest Florida (with and without *Fusarium* crown rot) (Ozores-Hampton et al. 2011).

In conclusion, temperature and RH are usually out of the grower's control. Sometimes the only thing a grower can do is wait for favorable weather conditions. If weather conditions are optimal and other growers are not having flower and fruit set problems, the grower should consider cultural causes of tomato blossom drop and poor fruit set. Selecting a suitable tomato variety, providing adequate N fertilizer, watering sufficiently, and controlling insects and diseases will potentially ensure high tomato yields. In Florida during the early fall growing season, growers can get around the heat issue by selecting heat-tolerant varieties.

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Table 1. Summary of optimal temperatures for tomato-flowering production and fruit set

Temperature (°F)	Duration	Effect
Daytime		
Above 85°F	Several days	Flower drop and fruit abort
Above 104°F	4 hours	Flower drop
Nighttime		
Above 70°F	Several days	Flower drop
Below 55°F	Several days	Flower drop

Table 2. Tomato variety recommendations based on disease incidence, flower production, and fruit set in Immokalee, FL

Month	Week 1	Week 2	Week 3	Week 4
No Fusarium crown rot				
August	'Phoenix'/FL 91	'Phoenix'/FL 91	'Phoenix'/FL 91	'Phoenix'/FL 91
September	FL 91/FL 47	FL 91/FL 47	FL 47	FL 47
October	FL 47	FL 47	FL 47	FL 47
November	FL 47	FL 47	FL 47	FL 47
December	FL 47/'Tygress'/SVR 200	FL 47/'Tygress'/SVR 200	'Tygress'/SVR 200	'Tygress'/SVR 200
January	FL 47/'Tygress'/SVR 200	FL 47/'Tygress'/SVR 200	FL 47/'Tygress'/ SVR 200	FL 47/'Tygress'/SVR 200
Fusarium crown rot				
August	'Phoenix'	'Phoenix'	'Phoenix'	'Phoenix'
September	'Sunkeeper'/'Crown Jewel'	'Sunkeeper'/'Crown Jewel'	'Sunkeeper'/'Crown Jewel'	'Sunkeeper'/'Soraya'
October	'Soraya'/BHN 585	'Soraya'/BHN 585	'Soraya'/BHN 585	'Soraya'/BHN 585
November	'Soraya'/BHN 585	'Soraya'/BHN 585	'Soraya'/BHN 585	'Soraya'/BHN 585
December	'Sebring'/BHN 585	'Sebring'/BHN 585	'Sebring'/BHN 585	'Sebring'/BHN 585
January	'Sebring'/BHN 585	'Sebring'/BHN 585	'Sebring'/BHN 585	'Sebring'/BHN 585
<i>Note: While this list includes a number of varieties currently popular with Florida growers, it is by no means a comprehensive list of all potential varieties that may be adapted to the state under the above conditions.</i>				