Imperial County Agricultural Briefs

Features From your Farm Advisors

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Table of Contents

Symptoms of Frost, Freezing and Chilling Injury on Vegetables

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The lower desert areas experience freezing temperatures several times during the winter and it is not uncommon winter vegetables injured. There are two types of injury that low temperatures can cause on vegetables. **Chilling injury** is what happens to some vegetable crops of tropical origin held at the wrong storage or transit temperature, but a temperature above 32°F (0°C). Generally these are temperatures around 41-50°F (12.5°C). Chilling injury occurs at temperatures well above freezing point. The tissue becomes weakened leading to cellular dysfunctions. Symptoms include surface lesions/pitting, internal discoloration, water soaking of the tissue, failure to ripen normally and increased susceptibility to decay organisms such as *Alternaria*. Maturity at harvest also affects the susceptibility to chilling injury in products such as tomatoes, honeydew melons and peppers.

The second type of injury is **Frost/freezing injury** and it can occur in a field when temperatures drop to or below 32°F (0°C). It can also occur during cold storage if temperatures were below the freezing point of the product. This exposure to freezing temperatures may have a drastic effect upon the entire plant or affect only a small part of the plant tissue, resulting in reduced yields or poor product quality. Ice formation on the plant and in the plant tissue is what causes the damage, especially when the tissue thaws. Postharvest researchers have worked on identifying the freezing temperatures for most crops and have published tables with the recommended optimum storage temperatures. No vegetable or fruit cold storage facility should be without these tables and they are available for download at the UC Davis Postharvest web site (http://postharvestucdavis.edu). Researchers have categorized fruits and vegetables into three groups based on their sensitivity to freezing (Table 1): most susceptible are those that are likely to be injured by one light freeze, moderately susceptible are those that will recover from one or two light freezes and least susceptible are those that can be lightly frozen several times without serious injury. Table 2 summarizes freezing symptoms for a range of common desert grown vegetables.

Table 1. Susceptibility of fresh fruits and vegetables to freezing injury.

Most susceptible	**Moderately susceptible**	**Least susceptible**
Asparagus	Broccoli	Brussels sprouts
Beans, snap	Carrots	Cabbage, mature and savory
Cucumbers	Cauliflower	Dates
Eggplant	Celery	Kale
Lemons	Grapefruit	Kohlrabi
Tomatoes	Grapes	Parsnips
Lettuce	Onion (dry)	Turnips
Limes	Oranges	Beets
Okra	Parsley	
Peppers, sweet	Radishes	
Potato	Spinach	
	Squash winter	

Table 2. Symptoms of freezing and chilling injury on some desert grown vegetables

Artichoke: Freezing injury will be initiated at 29.9°F (-1.2°C). Symptoms of light freezing injury are blistering of the cuticle and a bronzing of the outer bracts. This may occur in the field with winter-harvested buds. More severe freeze injury results in water soaked bracts and the heart becoming brown to black then gelatinous in appearance over time.

Asparagus: Freezing injury (water-soaked appearance leading to extreme softening) will likely result at temperatures of 30.9°F (-0.6°C) or lower.
The tip becomes limp and dark; the rest of the spear is water-soaked. Thawed spears become mushy. Chilling Injury occurs when spears are held more than 10 days at 32°F (0°C) and symptoms of chilling injury include loss of sheen or glossiness and graying of the tips. A limp, wilted appearance may be observed. Severe chilling injury may result in darkening near tips in spots or streaks

Snap Bean: Freezing Injury appears as water-soaked areas that subsequently deteriorate and decay. Freezing injury occurs at temperatures of 30.7°F (-0.7°C) or below. The typical symptom of chilling injury in snap beans stored below 41°F (5°C) but above freezing point for longer than 5-6 days is a general opaque discoloration of the entire bean. A less common symptom is pitting on the surface. The most common symptom of chilling injury is the appearance of discrete rusty brown spots which occur in the temperature range of 41-45°F (5-7.5°C). These lesions are very susceptible to attack by common fungal pathogens. Beans can be held about 2 days at 34°F (1°C), 4 days at 36°F (2.5°C), or 8-10 days at 41°F (5°C) before chilling symptoms appear. No discoloration occurs on beans stored at 50°F (10°C). Different snap bean varieties differ significantly in their susceptibility to chilling injury.

Bell Pepper: Freezing injury symptoms include dead, water-soaked tissue in part or all of the pericarp surface; pitting, shriveling, and decay follow thawing. Symptoms of chilling injury include surface pitting, water-soaked areas, decay (especially *Alternaria* spp.), and discoloration of the seed cavity.

Broccoli: will freeze if stored at 30.6°F (-0.6°C) to 30°F (-1.0°C). This may also occur if salt is used in the liquid-ice cooling slurry. Frozen and thawed areas on the florets appear very dark and translucent, may discolor after thawing and are very susceptible to bacterial decay. The youngest florets in the center of the curd are most sensitive to freezing injury. They turn brown and give off strong odors upon thawing.

Cabbage: Freeze damage appears as darkened translucent or water-soaked areas that will deteriorate rapidly after thawing. Freeze damage can occur if round cabbages are stored below 30.4°F (-0.9°C) and if Chinese cabbage is stored below 31°F (-0.6°C). Leaves become water-soaked, translucent, and limp upon thawing; the epidermis can also separate from the leaf as it does in lettuce.

Carrot: Freeze damage includes blistered appearance, jagged length-wise cracks. Carrot interior becomes water-soaked and darkened upon thawing. Freeze damage occur at below 29.5°F (-1.4°C) but can vary depending on the sugar content of the carrot.

Cauliflower: Freezing injury will be initiated at 30.6°F (- 0.8°C). Symptoms of freezing injury include a water-soaked and greyish curd and water-soaked or wilted crown leaves. The curd will become brown and gelatinous in appearance following invasion by soft-rot bacteria. These brown curds have a strong off-odor when cooked.

Celery: Freezing injury will be initiated at 31.1°F (- 0.5°C). Symptoms of freezing injury include a water-soaked appearance on thawing and wilted leaves. Mild freezing causes pitting or short streaks in the petiole which develop a brown discoloration with additional storage. Leaves and petioles appear wilted and water-soaked upon thawing. Petioles freeze more readily than leaves.

Eggplant: Freezing injury will be initiated at 30.6°F (- 0.8°C), depending on the soluble solids content. Symptoms of freezing injury include a water-soaked pulp becoming brown and desiccated in appearance over time. Eggplant fruit are chilling sensitive at temperatures below 50°F (10°C). At 41°F (5°C) chilling injury will occur in 6-8 days. Consequences of chilling injury are pitting, surface bronzing, and browning of seeds and pulp tissue. Accelerated decay by *Alternaria* spp. is common in chilling stressed fruit. Chilling injury is cumulative and may be initiated in the field prior to harvest.

Beet: Freezing injury symptoms include external and internal water-soaking; sometimes blackening of conducting tissue.

Garlic: Freezes at temperatures below 28°F (-2°C) due to its high solids content. Thawed cloves appear grayish-yellow and water-soaked.

Green Onion: Freezing injury will be initiated at 30.6°F (-1°C). Symptoms of freezing injury include a water-soaked appearance of bulb or leaves and wilted or gelatinous leaves, after thawing. The bulb will become soft or gelatinous in texture in outer tissue. Freeze injury is rapidly followed by bacterial soft-rot decay.

Lettuce Romaine and Crisphead: Freeze damage can occur in the field and cause separation of the epidermis from the leaf. This weakens the leaf and leads to bacterial decay during storage. Freeze damage can occur during storage if the lettuce is held at 31.7°F (<-0.2°C). This appears as darkened translucent or water-soaked areas that will turn slimy and deteriorate rapidly after thawing. The blistered dead cells of the separated epidermis on outer leaves become tan and there is increased susceptibility to physical damage and decay.

Okra: Freeze damage occurs at temperatures of 28.7°F (-1.8°C) or below. The typical symptoms of chilling injury in okra are discoloration, pitting, water-soaked lesions and increased decay (especially after removal to warmer temperatures, as during marketing). Different cultivars may differ in their susceptibility to chilling injury. Calcium dips and modified atmospheres have been reported to reduce chilling symptoms.

Onion: Freezing injury symptoms include soft water-soaked scales that rapidly decay from subsequent microbial growth. Thawed bulbs are soft, grayish-yellow, and water-soaked in cross section; often limited to individual scales.

Potato: Freezing injury will be initiated at 30.5°F (-0.8°C). Symptoms of freezing injury include a water-soaked appearance, glassiness, and tissue breakdown on thawing. Mild freezing may also result in chilling injury. Freezing injury may not be externally evident, but shows as gray or bluish-gray patches beneath the skin. Thawed tubers become soft and watery. Chilling injury can occur at storage temperatures near 32°F (0°C) after a few weeks and may result in a mahogany discoloration of internal tissue and eventually complete internal breakdown. Much longer periods (months) of storage are generally required for chilling injury at higher temperatures 36-41°F (2-5°C).

Radish: Radish ideally stored and transported just above the freezing point 30.5°F (-1.0°C), but freeze injury is not uncommon. Shoots become water-soaked, wilted, and turn black. Roots appear water-soaked and glassy, often only at the outer layers if the freezing temperature is not too low. Roots become soft quickly on warming and pigmented roots may "bleed" (lose pigment). Thawed tissues appear translucent; roots soften and shrivel.

Spinach: Freezing injury will be initiated at 31.5°F (-0.3°C). Freezing injury results in water soaking typically followed by rapid decay by soft-rot bacteria.

Tomato: Freezing injury will be initiated at 30°F (-1°C), depending on the soluble solids content. Symptoms of freezing injury include a watersoaked appearance, excessive softening, and desiccated appearance of the locular gel. In partially frozen fruits, the margin between healthy and dead tissue is distinct, especially in green fruits. Tomatoes are chilling sensitive at temperatures below 50°F (10°C) if held for longer than 2 weeks or at 41°F (5°C) for longer than 6-8 days. Consequences of chilling injury are failure to ripen and develop full color and flavor, irregular (blotchy) color development, premature softening, surface pitting, browning of seeds, and increased decay (especially Black mold caused by *Alternaria spp*.). Chilling injury is cumulative and may be initiated in the field prior to harvest.

Turnip: Freezing injury symptoms include small water-soaked spots or pitting on the surface. Injured tissues appear tan or gray and give off an objectionable odor.

Special thanks to:
Richard Smith, UCCE Monterey whom shared cauliflower freezing symptoms and Marita Cantwell, PhD, Postharvest Specialist, UCD whom shared her insights and experience.

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1. Commercial Cooling of Fruits, Vegetables and Flowers (2008)
James F. Thompson, F. Gordon Mitchell, Tom R. Rumsey, Robert F. Kasmire, Carlos H. Crisosto.
http://postharvest.ucdavis.edu/files/93530.pdf

2. Produce Fact Sheets: Recommendations for Maintaining Postharvest Quality.
UC Davis Postharvest Technology Center
http://postharvest.ucdavis.edu/PF/
This site has excellent pictures of freezing and chilling injury symptoms.

3. Chilling and Freezing Injury
C. Y. Wang, 2004. In Agriculture Handbook Number 66. The Commercial Storage of Fruits and Vegetables, Florist and Nursery Stocks (K.C. Gross, C. Y. Wang and M. E. Saltveit, eds.)
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Bachie Named Agronomy Advisor

As of Dec. 3, 2012, Oli Bachie will be the UCCE advisor for Imperial, Riverside and San Diego counties specializing in agronomy. His research will focus on crops such as alfalfa, wheat, sudangrass, bermudagrass, kleingrass, cotton and bio-energy crops.

Bachie recently earned his Ph.D. in plant biology at UC Riverside and has been working as an assistant research specialist in the UC Riverside Department of Nematology. His dissertation research explored alternative and ecologically desirable multipest – such as insects, nematodes and weeds – management strategies.

He has worked as a grower for Toronto urban forestry, graduate researcher at the University of Toronto and adjunct professor, network administrator and research specialist in San Diego at National University, American University and San Diego State University. He has also served as an adjunct professor of biology at the Victor Valley Community College for over 6 years. Prior to moving to North America, Bachie worked at the Ministry of Agriculture in Ethiopia as an expert in crop protection, weed management and crop production.

In addition to his Ph.D., Bachie holds a B.S. in plant sciences from Alamaya University (Ethiopia), an M.S. in weed sciences from the University of the Philippines, and an M.S. in forestry from the University of Toronto (Canada).

He will be based in the UCCE office in Holtville. Beginning on Dec. 3, Bachie can be reached at (760) 352-9474.

Improving Flood Irrigation Systems Efficiency

Khaled M. Bali

The advantage of flood irrigation system method is that it is inexpensive, both in terms of system costs and energy costs. The disadvantage is that its performance depends strongly on soil properties such as the infiltration rate and soil type. It is the most difficult irrigation method to manage efficiently because of its dependence on soil properties and its performance characteristics, and thus, a trial-and-error approach is normally used in its management.

Border or flood irrigation designs have several common features. They usually have slopes from 0.1% to 0.2% (1 to 2 ft per 1000 ft of run), include small 'border checks' (or small levies) 6-20" high, which confine water to an area from 10 to 200 feet wide so that water uniformly moves down the field. Field length in the direction of flow varies, but is usually determined by field constraints and soil characteristics. Sometimes flood systems are combined with 'corrugated' or 'bedded' systems which facilitate water movement and drainage on heavy soil.

Improving Flood Irrigation Systems

Flood irrigation systems can be improved by reducing deep percolation below the root zone and reducing surface runoff. However, measures to improve flood irrigation can be competitive, i.e. measures that reduce deep percolation can increase surface runoff and vise versa. Some measures commonly recommended include the following:

Increasing check flow rate: This commonly recommended measure reduces the advance time to the end of the field, thus decreasing variability in infiltration times along the field length. However, caution should be exercised with this approach such that the increased flow rate does not increase soil erosion.

Reducing field length: This is the most effective measure for improving uniformity and for reducing percolation rate below the root zone. Studies have shown that shortening the field length by one-half can reduce percolation by at least 50 percent. The distribution uniformity (DU) of infiltrated water will be increased by 10 to 15 percentage points compared with the normal field length. The new advance time to the end of the shortened field generally will be 30 to 40 percent of the advance time to the end of the original field length. Thus, the irrigation set time must be reduced to account for the new set time. A major problem with the above measure is the potential for increased surface runoff, which could be 2 to 4 times more runoff for the reduced length compared with the original field length (Hanson, 1989).

Selecting an appropriate irrigation water cutoff time: The amount of surface runoff or 'tailwater' can be greatly reduced by decreasing the cutoff time of the irrigation water. This is the most effective measure for reducing surface runoff. The cutoff time for a given field may need to be determined on a trial-and-error basis. The cutoff time should occur before the water reaches the end of the field except for sandy soils with high infiltration rates. However, the cutoff time should allow sufficient water to infiltrate the end of the field. Some guidelines, however, are to cut off the irrigation water when the water advance is about 60% of the field length for fine-textured soil, 70% to 80% for medium texture soil, and near 100% for coarse textured soil.

Recover surface runoff: Recirculation systems (commonly called tailwater-return systems), or storage-reuse systems, can dramatically improve efficiency of flood irrigation systems. Recirculation systems involve collecting the surface runoff in a small reservoir at the lower end of the field and then recirculation the water back to the "head" of the field during irrigation, using a low lift pump and a buried or portable pipeline. The recirculated water should be used to irrigate an additional area of the field. Simply recirculating the runoff back to the same irrigation set that generated the runoff results only in temporarily storing the water on the field and will result in an increased rate of runoff.

Similarly, a storage/reuse system involves storing all of the surface runoff from a field and then using that water to irrigate another field at the appropriate time. This approach requires a farm with multiple fields, a relatively large reservoir, and distribution systems to convey surface runoff to the storage reservoir and to convey the stored water to the desired fields.

Care should be taken that water quality is not degraded from the storage-reuse systems. Pesticides have been found to infiltrate groundwater on some soil types, primarily from catchment basins, steps to seal basins from subsurface infiltration may be effective at preventing contamination.

Source: Irrigated Alfalfa Management for Mediterranean and Desert Zone. 2008. UCANR. Publication 3512. Chapter 7. Irrigating Alfalfa in Arid Regions.

Current Status and Management Efforts For the Introduced TYLCV in California

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Tomato yellow leaf curl virus (TYLCV) a whitefly-transmitted geminivirus (also known as begomoviruses) that is one of the most damaging viruses known to infect tomatoes. TYLCV causes the tomato yellow leaf curl (TYLC) disease, which is characterized by stunted growth and leaf yellowing and curling; this disease can cause 100% losses in tomato fields. Originally a virus found only in Old World locations (e.g., the Mediterranean basin, Asia and Africa), it was inadvertently introduced into the New World in the early 1990s and it has since spread throughout the Caribbean basin, the southeastern United States and Mexico). More recently, the virus also has been found in Arizona, Hawaii and the Rio Grande Valley of Texas. In March 2007, TYLCV was first detected in California from tomato plants showing TYLC-like symptoms collected by Eric Natwick from a noncommercial greenhouse in Brawley, California. Dr. Robert Gilbertson, Department of Plant Pathology, UC Davis, confirmed the presence of TYLCV in these diseased tomatoes. Because TYLCV posed a threat to commercial tomato production statewide, CDFA and the Imperial County Agricultural Commissioner initiated efforts to contain and eradicate TYLCV in Imperial County. However, by the fall of 2008, TYLCV was found in the Coachella Valley in Riverside County, CA. Since 2008, annual surveys of commercial tomato fields in Imperial Valley have revealed TYLCV-infected plants, albeit at relatively low incidences in most fields. However, TYLCV has not been detected in tomato and pepper transplants produced in Imperial County, nor has TYLCV been found elsewhere in California. This is very important because growers throughout California obtain tomato and pepper transplants produced in Imperial County and Yuma, Arizona. Thus, efforts have been made to monitor these transplants for whiteflies and TYLCV. To date, TYLCV has not been found in any of these transplants, due to the diligence of the transplant growers in California to maintain clean culture via sanitation practices, and the fact that populations of whiteflies are low or non-existent during the time that transplants are produced. Consistent with the results of these surveys, TYLCV has not been found in the major tomato growing areas of California, including fields established with transplants from Imperial County and Yuma. Thus, although TYLCV has not been eliminated from California, the combined efforts of CDFA, UC Cooperative Extension, UC Davis, Imperial County Agricultural Commissioner's Office, the tomato transplant industry in southern California, the California Tomato Research Institute (CTRI) and the California League of Food Processors (CLFP) have provided information to growers about the disease, supported extensive surveys for TYLCV spread and helped contain the virus to the Imperial Valley and Coachella Valley.

However, growers, transplant producers, PCAs and others associated with the tomato industry need to be looking for symptoms of TYLCV. Typical symptoms of TYLC disease in tomato are stunted and unusually erect upright growth and yellow (chlorotic) leaf edges and interveinal areas, upward leaf cupping and crumpling, reduced leaf size, and flower drop. TYLCV can have a severe impact on tomato production. Plants infected at early stages of growth (before flowering) won't bear fruit, and growth will be severely stunted. However, TYLCV cannot be identified based only on symptoms, because other viruses can cause TYLC-like symptoms, such as *Alfalfa mosaic virus*, curly top viruses and *Tomato mosaic virus*. Therefore, crop or weed plants suspected of having TYLCV infection can be brought to a UC Cooperative Extension Office in your county or your local Agricultural Commissioner's Office and they will be shipped to Dr. Robert Gilbertson at UCD or to CDFA to confirm the presence of TYLCV.

An effective IPM program for TYLCV has been developed in areas where the virus in endemic, and this program involves tomato-free periods, planting disease-free transplants and resistant varieties, whitefly management and extensive sanitation. However, it is important to emphasize that there are a number of factors **that do not favor establishment of the virus in the major tomato-producing areas of California**. First, *Bemisia* whiteflies are not typically found in these tomato-producing areas because the insect is intolerant of the cold winter temperatures in these locations (e.g., Colusa, Fresno, Kings, Merced, San Joaquin and Yolo Counties). Second, the winter season provides a "natural" tomato-free period, usually from late November through early February. This break eliminates the primary host of the virus, which is tomato. TYLCV can infect other crops such as beans and peppers, but it does so less efficiently (e.g., many types of beans and peppers show no symptoms when infected with the virus). Even if the virus were able to overwinter in other (weed) hosts, it does so inefficiently, resulting in delayed appearance of the virus and less economic damage to tomato crops. However, in areas subject to high whitefly populations, such as Imperial Valley and Riverside Counties, late-planted tomatoes are likely to be impacted by TYLCV.

Therefore, based upon our knowledge of TYLCV in California to date, the following procedures are recommended for management of TYLC disease:

1) Produce and plant virus- and whitefly-free tomato and pepper transplants. Transplants should be treated with Capture (bifenthrin) or Venom (dinotefuran) for whitefly adults and Oberon for eggs and nymphs. Imidacloprid or thiamethoxam should be used in transplant houses at least 7 days before shipping. Transplants should be produced in areas well away from tomato and pepper production fields. Surveys of transplants and fields for whiteflies and TYLC-like symptoms are highly recommended, with any plants suspected of being infected with TYLCV testedby UCD or CDFA.

2) Use a neonicotinoid insecticide, such as dinotefuran (Venom) imidacloprid (AdmirePro, Alias, Nuprid, Widow, and others) or thiamethoxam (Platinum), as a soil application or through the drip irrigation system at the time of transplanting of tomatoes or peppers. After the efficacy of the neonicotinoid insecticide application begins to decline, the secondary spread of whiteflies will need to be controlled. Monitor whitefly populations throughout the season, treating when present. Rotate insecticide classes for insecticide resistance management (IRM). Foliar insecticide treatments used in IRM for whitefly control include: Capture, a pyrethroid; foliar neonicotinoid insecticides dinotefuran (Venom), imidacloprid (Provado), and thiamethoxam (Actara), but do not use if a neonicotinoid insecticide was applied as a soil or drip irrigation treatment; insect growth regulators such as pyriproxyfen (Knack) and buprofezin (Courier); insecticidal soap; and crop oils. A highly UV-reflective mulches (metalized) and low rates of crop oil (0.25 -0.50 percent) can also be used as whitefly repellents to reduce whitefly feeding and virus transmission.

3) Sanitation is very important for preventing the migration of whitefly adults and the spread of TYLCV. Rogue tomato plants with early symptoms of TYLCV from fields by placing infected-looking plants in plastic bags immediately at the beginning season, especially during first 3-4 weeks. Maintain good weed control in the field and surrounding areas. Prevent the spread of any whiteflies to healthy plants. After harvest of tomato and pepper fields, plants should be promptly destroyed by deep plowing or some other method. Also destroy old harvested plants and volunteers of melons and cotton immediately after harvest to reduce whitefly migration to tomatoes.

CIMIS REPORT AND UC DROUGHT MANAGEMENT PUBLICATIONS

Khaled Bali and Sharon Sparks*

California Irrigation Management Information System (CIMIS) is a statewide network operated by California Department of Water Resources. Estimates of the daily reference evapotranspiration (ET_o) for the period of December 1 to February 28 for three locations in the Imperial County are presented in Table 1. ET of a particular crop can be estimated by multiplying ET_o by crop coefficients. For more information about ET and crop coefficients, contact the UC Imperial County Cooperative Extension Office (352-9474) or the IID, Irrigation Management Unit (339-9082). Please feel free to call us if you need additional weather information, or check the latest weather data on the worldwide web (visit http://tmdl.ucdavis.edu and click on the CIMIS link).

Table 1. Estimates of daily Evapotranspiration (ET_o) in inches per day

Station	December		January		February	
	1-15	16-31	1-15	15-31	1-15	16-28
Calipatria	0.07	0.07	0.08	0.09	0.12	0.14
El Centro (Seeley)	0.06	0.06	0.08	0.09	0.12	0.14
Holtville (Meloland)	0.06	0.06	0.08	0.09	0.12	0.14

*Imperial Irrigation District.

Link to UC Drought Management Publications

http://ucmanagedrought.ucdavis.edu/