atmosphere. The normal metabolism of a plant can change, depending on the severity and duration of the stress. Water stress often reduces vegetative and reproductive growth, photosynthesis, transpiration, and ion uptake and translocation, and it may render the plant more susceptible to insects and diseases. Drought before anthesis may delay flowering, reduce plant stature, and change sex expression (from female to male). Water stress while fruit are enlarging can reduce both yield and quality at harvest and during postharvest storage.

In cucumber, as well as other cucurbits, reductions in fruit yield and quality due to water deficits depend on the severity and duration of the stress. Fruits that enlarge during soil moisture deficits are often smaller and softer than normal and can be distorted (Plate 71A). Moreover, levels of fruit sugars, minerals, and vitamins in many cucurbits can be drastically altered (usually lowered) by drought episodes. For example, the frequency and severity of pillowy fruit disorder in cucumber is influenced by plant water stress and postharvest storage. This anomaly appears as brown, water-soaked lesions in processing cucumbers and can result in significant product loss (Plate 71B). Like many plant stresses, soil water deficits can cause changes in metabolite transport. The frequency and intensity of pillowy fruit disorder is associated with lower levels of calcium in affected fruit tissue. A similar abnormality has been described in watermelon.

Excess Water

Under flooding, plant roots receive decreasing amounts of oxygen, depending on the duration and severity of the stress episode. Respiratory and metabolite transport systems are highly sensitive to and adversely affected by oxygen depletion. Crop damage due to excess water is not as frequent and widespread as drought. Excess water is usually a result of unusually frequent or above-normal precipitation in a short time. Management of high volumes of excess water is often more problematic in heavy than in sandy loam soils.

Plants react to oxygen deficits and low mineral (e.g., nitrogen) concentrations as nutrients are washed through the soil horizon. Thus, cucurbits held for extended periods at near 100% soil water saturation can become yellow and stunted. Cucurbit species exhibit different responses to excess water during growth (Plate 71C). Cucumber and melon (but not watermelon and squash) produce aerial roots at the base of the plant, at or just above the water line, when exposed to flooding.

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(Prepared by J. E. Staub)

Pollination Problems

Field-grown cucurbits require pollination for fruit development. The exception is parthenocarpic cucumbers, often used in greenhouse production. In order to get proper pollination and avoid misshapen fruits (nubbins, crookeds, and constrictions) (Plate 72) growers should try to provide one bee per plant, or 2.5 strong, active hives per hectare. More bees are required for high-density plantings (e.g., five hives per hectare for once-over machine harvest of pickling cucumbers).

Cucurbits are generally not as attractive to bees as other crops, such as clover. Thus, bees should not be put into cucurbit fields until after the crop has begun to flower, to prevent the bees from establishing foraging patterns in other crops. Insecticides should not be applied near hives or in the fields when the bees are working (from sunrise until early afternoon). Pollination is less effective at temperatures above 32°C, so cucurbit crops should be planted to avoid flowering during times of the year when temperatures reach that range.

The best way to get good pollination is to bring beehives into the production field. Bee attractants have been tried, but they are not as effective as good bee management. Other factors are involved in proper pollination. It has been observed that some cultivars (such as Calypso pickling cucumber) set fruit better than others at high temperatures during flowering. Newer cultivars are generally more resistant to internal defects caused by inadequate pollination. If there are problems with pollination in gynoecious cultivars, the percentage of pollenizer can be increased, or an early-flowering pollenizer can be substituted in the hybrid blend. Finally, overhead irrigation may help reduce the temperature in the field during critical times and thus enhance pollination.

Selected Reference

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(Prepared by T. C. Wehner)

Temperature Stress

Abnormally high or low temperatures may cause disruptions in normal physiological and metabolic processes. Temperature stress may affect cell growth, cell wall synthesis, hormonal relationships, protein synthesis, stomatal opening (respiration), and carbon dioxide assimilation (photosynthesis).

Cucurbits require warm conditions for growth. For example, cucumber requires temperatures above 16°C for seed germination, seedling emergence, and plant growth and development. The optimum temperature for germination of many cucurbit species is around 32°C, and growth is slowed at higher temperatures.

At high temperatures (38–45°C), growth of plants in the three- to six-leaf stage may be slowed, and leaf margins may appear yellow, depending on the species, cultivar, length of exposure, and other environmental factors. At extremely high temperatures (42–45°C) young leaves may appear light green to yellowish after relatively short exposures (24–48 hr). High temperatures during fruit enlargement often result in decreased yield and fruit quantity, depending on the degree and duration of the stress episode. Flowers and fruit abort, and sex expression changes from pistillate to staminate if the temperature rises above 38°C for any appreciable time.

Low temperatures (10–17°C) can delay seed germination and seedling emergence and cause a decrease in plant growth. Usually, there are no lesions on leaves, but stems are shorter and leaves smaller. Exposure of plants to low temperatures (below 17°C) just prior to or during anthesis may cause a shift in sex expression (to a higher frequency of male flowers). Changes in sex expression are dependent on the genotype (i.e., the effect of modifying genes on major sex-determining genes).

Temperatures below 10°C cause chilling injury in many cucurbit species. The initial symptoms are white areas on cotyledons and white or light brown margins on fully expanded leaves (Plate 73A). Preliminary evidence suggests that watermelon and squash are more resistant, luffa gourd and melon are intermediate, and cucumber is most susceptible (Plate 73B). More severe chilling results in necrotic lesions over large areas of the leaves, ultimately causing the death of the plant. Temperatures below 10°C can cause chilling injury in harvested fruit (see Part IV, Postharvest Handling).

Chilling injury (below 10°C) is increased by the following conditions: 1) longer duration of chilling, 2) lower temperature, 3) higher-intensity light during chilling, 4) high wind speed during chilling, and 5) higher growth temperature before chilling occurs. The injury is worse in susceptible cultivars.

Control measures to prevent chilling injury include planting resistant cultivars, selecting a safe planting date (seeding after frost danger is over), and using plastic mulch and row covers to provide protection from chilling. Also, overhead irrigation may provide some measure of protection during frost.

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(Prepared by J. E. Staub and T. C. Wehner)

Damage Caused by Arthropods

Mites

Two species of spider mites—the twospotted spider mite, *Tetranychus urticae* Koch, and the carmine mite, *T. cinnabarinus* Boisduval—are important foliar pests of cucurbits throughout the United States. Other species may also feed on stems and foliage but are of minor importance.

Life History and Description

Both *T. urticae* and *T. cinnabarinus* are small mites found mainly on the lower surface of leaves (Plate 74A). The adult female is the largest life stage (0.45 mm) and has eight legs and a robust body. The male is slightly smaller and has a pointed abdomen. There are five life stages: the egg, six-legged larvae, eight-legged protonymph, deutonymph, and adult. Development from egg to adult can occur in as little as 6 days. The female is capable of producing up to 200 eggs, resulting in population explosions in a short time.

Spider mites overwinter in temperate areas as diapausing females (Fig. 9). In the spring, adult females become active, begin to feed, and lay eggs. Fertilized eggs produce female mites, and unfertilized eggs produce males. If an overwintered female has not been fertilized, she lays male eggs, and the males that hatch from these eggs mature and mate with her. Therefore, a second generation can be produced rapidly. As the weather warms, multiple, overlapping generations are produced. Spider mites may produce 20 or more generations per growing season. In the fall, females migrate (by wind or walking) to overwintering sites, typically in the soil or in field debris. In more tropical or subtropical areas, mites do not overwinter, and they reproduce year-round.

Damage

Spider mites damage cucurbits by puncturing cells of the leaves, mainly on the lower surface. They extract plant juices and chlorophyll, interrupting the normal production of photosynthate. An early sign of infestation is stippled areas on foli-

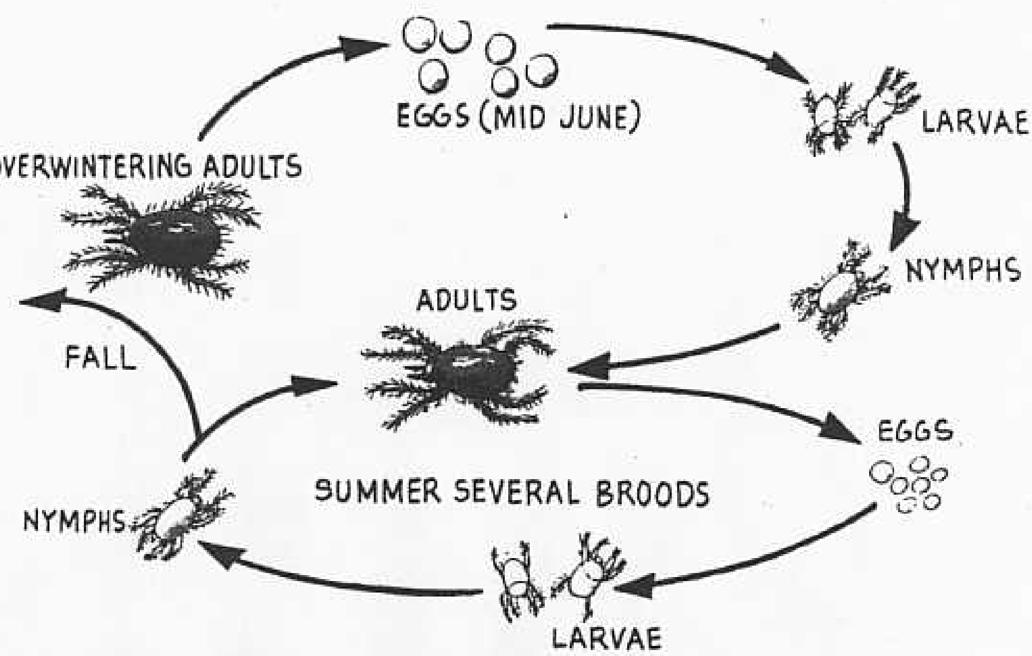

Fig. 9. Life cycle of spider mites. (Courtesy T. M. Perring)