UF IFAS Extension UNIVERSITY of FLORIDA

UF/IFAS PEER REVIEWED HS1499
doi.org/10.32473/edis-hs1499-2026

Quick Guide to Environmental Factors Impacting Subtropical and Tropical Fruit Crops in Florida[1]

Jonathan H. Crane, Bruce Schaffer, Young Gu Her, Haimanote Bayabil, Jeff Wasielewski, and Clyde Fraisse[2]

Introduction

Commercial tropical fruit crop acreage is expanding in Florida outside the traditional extreme south Florida and coastal counties. This largely results from the significantly warmer climate, less frequent freezing events, and less severity and duration of freezing events throughout the state, especially south-central counties. In addition, as the loss of citrus acreage continues, citrus growers and entrepreneurs are seeking alternative crops to remain in business. The successful establishment and maintenance of tropical and subtropical fruit crops in Florida depend on the crop's tolerance to critical abiotic factors, including tolerance to flooded or waterlogged soil conditions, its ability to withstand high soil and irrigation water salinity, and its high and low temperature ranges for growth, flowering, and production. This publication aims to provide commercial growers, Extension faculty, and urban residents with a quick guide to understanding the impacts of environmental factors on subtropical and tropical fruit crops grown in Florida.

High and Low Temperature Ranges for Growth, Flowering, and Production

Selection of a fruit crop for a specific area should consider the potential high and low extreme temperatures, as well as the general mean temperatures of the area, the known ideal optimum temperatures, and the tolerance for extreme high and low temperatures of the proposed fruit crop.

The optimum growing temperature range is the range of temperatures at which a plant grows best. In many instances, these are the ideal year-round temperatures for the crop (e.g., Annona, dragonfruit, mamey sapote, and papaya). In contrast, some fruit crops (e.g., lychee, longan, and mango) have optimum vegetative growth and fruit development temperatures but optimize their flowering and fruit production only after exposure to environmental conditions that cause them to go dormant (called quiescence). Usually, exposure to cool or cold non-freezing temperatures and/or drought conditions during the fall and winter months induces quiescence.

Temperatures for Flowering

Fruit trees generally need a period of dormancy to flower and fruit successfully. Dormancy can be defined as a period of no active (visible) stem growth. Dormancy for many tropical and subtropical fruit crops occurs in response to cool temperatures (above freezing but below species or cultivar-specific thresholds). Technically, this dormancy is termed quiescence (i.e., environmentally imposed dormancy). The length of dormancy requirement varies between and within fruit crop species. For example, 'Keitt' and 'Tommy Atkins' mango trees require a longer period (two to four months) of dormancy to flower well compared to 'Edwards' and 'Haden' cultivars (approximately one to two months). Lychee, in particular, needs a long period of dormancy (two to five months) to flower and fruit well and also requires exposure to cool temperatures (upper 40s to lower 60s) just before or during panicle emergence. Because of the generally warmer climate brought on by global climate change, lychee now rarely flowers or fruits well in Miami-Dade County, and trees repeatedly flush vegetatively because shoot growth is not suppressed by cool temperatures. In contrast, summer high temperatures greater than about 92°F may cause flower abortion in passionfruit. Therefore, careful study of the optimum temperatures for growth, flowering, and fruiting, as well as tolerance to high and low temperature extremes, should be investigated when selecting a fruit crop.

Chilling and Cold Tolerance

Historically, attempts to commercially produce (or at least trial) many tropical and subtropical fruit crops in north, central, and south Florida have shown that successful tropical fruit production was limited to southeastern (Miami-Dade, Broward, Palm Beach [southeastern end of Lake Okeechobee, eastern-to-central Palm Beach County]) and southwestern (Lee County [Pine Island primarily] and Manatee County [Bradenton area]) coastal areas of the state. There are other coastal counties where small plantings of tropical and subtropical fruit crops are grown (e.g., Martin, Indian River, and Brevard Counties). While some tropical and subtropical fruit crops have been harmed by periodic freezing temperatures in these areas, most are severely damaged or killed outside these regions. Indisputably, the general climate has warmed throughout central and south Florida over the past 20 years, and the frequency and/or duration of freeze events have decreased. This has led to new interest in expanding tropical and subtropical fruit production in Florida outside of its historic range. Currently, the acreage of cold-sensitive fruit crops such as guanábana (soursop), caimito, and sugar apple has expanded in Miami-Dade County. Production of these crops has been successful in the area, despite brief cold (e.g., temperatures of 32°F–37°F) and chilling (i.e., temperatures below ~55°F) temperature events, which have caused some crop damage (e.g., defoliation, some dieback). In contrast, the acreage of three slightly less cold-sensitive fruit crops, guava, dragonfruit, and passionfruit, has recently expanded along coastal areas from Sarasota and Brevard Counties south.

Freezing Temperatures

There are four components to freeze events: 1) the duration (how long an event is at or below 32°F), 2) the frequency (how often the events occur), 3) the depth of the freezing temperatures (the lowest temperature experienced), and 4) when the freezing or chilling temperatures occur (e.g., during bloom or dormancy). For example, chilling temperatures (i.e., above freezing but below ~45°F in 2022 in Homestead) occurred during the mango flowering period, resulting in a drastically reduced fruit set and harvest. Despite the climate warming trend over the past 20 years, freeze events can and do still occur (even in Miami-Dade County). Most disconcerting is the lack of grower planning for potential freeze and/or frost events. Planning includes the establishment of appropriate irrigation infrastructure (e.g., high volume systems) or the establishment of a bedded planting with high-capacity pumps to move water between tree rows (ditch) and to drain the water off quickly. For tropical and subtropical fruit crops, there is limited experience with the use of microsprinkler systems with or without tree trunk covers for young tree freeze protection, and many new plantings only have microsprinkler systems with low pumping capacity that can only irrigate parts of the grove at one time. For more information, see EDIS publication HS1375, "Irrigation System Descriptions for Tropical and Subtropical Fruit Crops in Florida." Prior to purchasing land and/or establishing an irrigation system, producers need to investigate the availability and quality of the water in their water management district. Some areas do not permit the use of high volumes of water, thus limiting the options for cold/freeze protection with water. Producers should know the rules of their district and plan accordingly before establishing a new grove.

Constant Winds

Some fruit crop species are sensitive to constantly windy conditions, which are sometimes called trade winds. Although the wind speeds may not be great (e.g., 10 to 15 mph or less), they can reduce young carambola, caimito, and Annona tree, passionfruit vine, and papaya plant establishment and growth through their negative effect on leaf water loss, nutrient uptake, and mechanical plant damage. Planting these fruit crops in wind-protected or low-wind-speed areas vastly improves their crop growth and production.

Tolerance of Flooded or Waterlogged Soils

Higher elevation areas are less prone to flooding than lower elevation areas. The potential frequency and duration of soil flooding or saturation increase in low-lying areas or in areas with a hardpan several inches to several feet down in the soil profile. Flatwoods areas are particularly vulnerable, and the citrus in these areas are planted on beds to elevate the tree roots above moderate flooding depths. Bedding, land contouring, and passive drainage systems should be considered prior to establishing a tropical or subtropical fruit grove in these areas. Also, sufficiently large pumps to move water in and out of drainage ditches should be established prior to planting. Subtropical and tropical fruit crops vary in their tolerance to constantly saturated soil conditions and flooding. In general, flooding is more damaging when combined with high-temperature periods or if the tree has fruit. For example, guava and sapodilla are considered flood-tolerant (i.e., they can survive several days to a few weeks); however, their growth and fruit production may be reduced, and root diseases may result in tree damage or death. Mango, lychee, longan, and carambola are moderately flood-tolerant, but growth and production may be reduced, and root disease may cause tree decline or death. In contrast, avocado, papaya, and passionfruit do not tolerate constantly wet or flooded soil conditions and may be severely damaged or killed after 48–72 hours of overly wet soil conditions. One strategy to reduce avocado tree damage after flooded soil conditions is to prune trees (i.e., remove one-third to half of the canopy) immediately after the flooding event to reduce the canopy demand for water and nutrients. For more information on the flood tolerance of tropical and subtropical fruit crops, see EDIS publication HS957, "Managing Your Tropical Fruit Grove Under Changing Water Table Levels."

Saline Soils and Water

Very few fruit crops tolerate saline soils and/or water. For example, guava and dragonfruit are considered tolerant to saline soil and water conditions, whereas avocado, mango, and passionfruit are not. For more information on the management of saline soil and/or water, see EDIS publication AE572, "Saltwater Intrusion and Flooding: Risks to South Florida's Agriculture and Potential Management Practices." In some coastal areas (e.g., Pine Island), there is potential for saltwater intrusion into the aquifers and wells, and there are no economic or effective cultural practices to mitigate or prevent crop damage from saline irrigation water. Desalination of saline contaminated soils requires fresh water, and desalination of brackish water for irrigation is expensive. In areas prone to storm surges (from tropical storms or sea level rise), bedding and passive and/or active drainage infrastructure should be established ahead of planting to help reduce the potential for soil contamination by saline water.

Drought Tolerance

Tropical fruit trees vary in their drought tolerance; however, the growth, production, and fruit quality of even drought-tolerant species may be reduced. For example, mangoes and sapodillas reportedly tolerate several days to weeks of drought, but this may be affected by tree size and the extent of their root system. In contrast, papaya and banana do not tolerate even short-term drought conditions (i.e., they survive a few days of drought, but it may lead to leaf drop and yield reduction), which may result in dramatic delays and reduced flowering. For more information on the drought tolerance of tropical and subtropical fruit crops, see EDIS publication HS957, "Managing Your Tropical Fruit Grove Under Changing Water Table Levels." Optimally, orchards should have an appropriately designed and managed irrigation system to avoid prolonged soil drought conditions, especially from flowering to the harvest period.

The following tables summarize important environmental factors that producers should consider prior to establishing an orchard for commonly planted tropical or subtropical fruits.

References by Crop and Environmental Factor

References

Al Harthy, K. M., H. S. Aishah, A. Yahya, I. Roslan, and R. Al Yahyai. 2018. "Effects of Saline Irrigation Water on Morphological Characteristics of Banana (*Musa* spp.)." *International Food Research Journal* 25: S195–S200.

Al-Yahyai, R., B. Schaffer, and F. S. Davies. 2005. "Physiological Responses of Carambola Trees to Soil Water Depletion." *HortScience* 40 (7): 2145–2150. https://doi.org/10.21273/HORTSCI.40.7.2145

Arpaia, M. L., G. S. Bender, L. Francis, J. A. Menge, J. S. Shepherd, V. W. Smothers. 2012. Avocado Production in California: A Cultural Handbook for Growers. 2nd edition. Book One. UC Cooperative Extension and The California Avocado Society.

Basso, C., G. Rodríguez, G. Rivero, R. León, M. Barrios, and G. Díaz. 2019. "Respuesta del cultivo de maracuyá (*Passiflora edulis* Sims) a condiciones de estrés por inundación" [Response of Yellow Passion Fruit (*Passiflora edulis* Sims) Under Flooding Conditions]. *Bioagro* 31 (3): 185–192.

Ben-Asher, J., P. S. Nobel, E. Yossov, and Y. Mizrahi. 2006. "Net CO_2 Uptake Rates for *Hylocereus undatus* and *Selenicereus megalanthus* Under Field Conditions: Drought Influence and a Novel Method for Analyzing Temperature Dependence." *Photosynthetica* 44 (2): 181–196. https://doi.org/10.1007/s11099-006-0004-y

Campbell, C. W., R. J. Knight, Jr., and R. Olszack. 1985. "Carambola Production in Florida." *Proceedings of the Florida State Horticultural Society* 98: 145–149.

Campbell, C. W., R. J. Knight, Jr., and N. O. Zareski. 1977. "Freeze Damage to Tropical Fruits in Southern Florida in 1977." *Proceedings of the Florida State Horticultural Society* 90: 254–257.

Carr, M. K. V., and C. M. Menzel. 2014. "The Water Relations and Irrigation Requirements of Lychee (*Litichi chiensis* Sonn.): A Review." *Experimental Agriculture* 50 (4): 481–497. https://doi.org/10.1017/S0014479713000653

Cervantes, K. N. G., E. A. Mesias, E. B. Montaño, and J. R. Osorio. 2015. "Effect of Waterlogging on the Alcohol Dehydrogenase Activity in Yellow Passion Fruit Roots *Passiflora edulis* var. *Flavicarpa*." *Colombian Journal of Biotechnology* 17 (2): 112–120.

Chao, C-C. T., and R. E. Paull. 2008. "Lauraceae, *Persea americana*, avocado." In *The Encyclopedia of Fruit and Nuts*, edited by J. Janick and R. E. Paull. CABI International.

Crane, J. H., C. F. Balerdi, and B. Schaffer. 2016. "Managing Your Tropical Fruit Grove Under Changing Water Table Levels: HS957/HS202, rev. 11/2016." *EDIS* 2016 (10). https://doi.org/10.32473/edis-hs202-2003

de Oliveira, M. M. T., L. Shuhua, D. S. Kumbha, U. Zurgil, E. Raveh, and N. Tel-Zur. 2020. "Performance of *Hylocereus* (Cactaceae) Species and Interspecific Hybrids Under High-Temperature Stress." *Plant Physiology and Biochemistry* 153: 30–39. https://doi.org/10.1016/j.plaphy.2020.04.044

Deshmukh, N. A., R. K. Patel, S. Okram, H. Rymbai, S. S. Roy, and A. K. Jha. 2017. "44. Passion fruit

(*Passiflora* spp.).” In *Underutilized Fruit Crops: Importance and Cultivation*, edited by S. N. Ghosh, A. Singh, and A. Thakur. Part II. Jaya Publishing House.

de Sousa, G. G., S. B. Sousa, A. C. da S. Pereira, V. B. Marques, M. L. G. da Silva, and J. da S. Lopes. 2021. “Efeito da água salina e sombreamento no crescimento de mudas de ‘pitaya’” [Effect of Saline Water and Shading on Dragon Fruit (Pitaya) Seedling Growth]. *Revista Brasileira de Engenharia Agrícola e Ambiental* 25 (8): 547–552. https://doi.org/10.1590/1807-1929/agriambi.v25n8p547-552

Dubrovina, I. A., and F. Bautista. 2014. “Analysis of the Suitability of Various Soil Groups and Types of Climates for Avocado Growing in the State of Michoacán, Mexico.” *Eurasian Soil Science* 47 (5): 491–503. https://doi.org/10.1134/S1064229314010037

Ebert, G. 2000. “Salinity Problems in (Sub-) Tropical Fruit Production.” *Acta Horticulturae* 531: 99–105. https://doi.org/10.17660/ActaHortic.2000.531.14

Fu, X.-Y., S.-X. Peng, S. Yango, et al. 2012. “Effects of Flooding on Grafted Annona Plants of Different Scion/Rootstock Combinations.” *Agricultural Sciences* 3 (2): 249–256. https://doi.org/10.4236/as.2012.32029

George, H. L., F. S. Davies, J. H. Crane, and B. Schaffer. 2002. “Root Temperature Effects on 'Arkin' Carambola (*Averrhoa carambola* L.) Trees II. Growth and Mineral Nutrition.” *Scientia Horticulturae* 96 (1–4): 67–79. https://doi.org/10.1016/S0304-4238(02)00091-2

Goenaga, R. 2017. “Yield and Fruit Quality Traits of Carambola Cultivars Grown at Three Locations in Puerto Rico.” *HortTechnology* 17 (4): 604–607. https://doi.org/10.21273/HORTTECH.17.4.604

Groff, G. W. 1921. *The Lychee and Lungan.* Orange Judd Company.

Groff, G. W. 1943. “Some Ecological Factors Involved in Successful Lychee Culture.” *Proceedings of the Florida State Horticultural Society* 56: 134–155.

Hatton, T. T., Jr., and W. P. Reeder. 1963. “Effects of the December 1962 Freeze on Lula and Taylor Avocado Fruits.” *Proceedings of the Florida State Horticultural Society* 76: 370–374.

Higuchi, H., N. Utsunomiya, and T. Sakuratani. 1998. “Effects of Temperature on Growth, Dry Matter Production and CO_2 Assimilation in Cherimoya (*Anona cherimola* Mill.) and Sugar Apple (*Annona squamosa* L.) Seedlings.” *Scientia Horticulturae* 73 (2–3): 89–97. https://doi.org/10.1016/S0304-4238(97)00142-8

Ismail, M. R., S. W. Burrage, H. Tarmizi, and M. A. Aziz. 1994. “Growth, Plant Water Relations, Photosynthesis Rate and Accumulation of Proline in Young Carambola Plants in Relation to Water Stress.” *Scientia Horticulturae* 60 (1–2): 101–114. https://doi.org/10.1016/0304-4238(94)90065-5

Ismail, M. R., and K. M. Noor. 1996. “Growth and Physiological Processes of Young Starfruit (*Averhoa carambola* L.) Plants Under Soil Flooding.” *Scientia Horticulturae* 65 (4): 229–238. https://doi.org/10.1016/0304-4238(96)00897-7

Joyner, M. E. B., and B. Schaffer. 1989. “Flooding Tolerance of 'Golden Star' Carambola Trees.” *Proceedings of the Florida State Horticultural Society* 102: 236–239.

Júnior, E. B., Coelho, E. F., K. S. Gonçalves, and J. L. Cruz. 2020. “Comportamento fisiológico e vegetativo de cultivares de bananeira sob salinidade da água de irrigação” [Physiological and Vegetative Behavior of Banana Cultivars Under Irrigation Water Salinity]. *Revista Brasileira de Engenharia Agrícola e Ambiental* 24 (2): 82–88. https://doi.org/10.1590/1807-1929/agriambi.v24n2p82-88

Krezdorn, A. H. 1970. “Evaluation of Cold-Hardy Avocados in Florida.” *Proceedings of the Florida State Horticultural Society* 83: 382–386.

Kwee, L. T., and K. K. Chong. 1990. “Agroecological Requirements.” In *Guava in Malaysia: Production, Pests, and Diseases.* Tropical Press. ISBN 967-73-0051-2.

Leal, F., and R. E. Paul. 2022. “The Soursop (*Annona muricata*): Botany, Horticulture, and Utilization.” *Horticultural Review* 63 (2): 362–389. https://doi.org/10.1002/csc2.20894

Le Bellec, F., F. Vaillant, and E. Imbert. 2006. “Pitahaya (*Hylocereus* spp.): A New Fruit Crop, a Market with Potential.” *Fruits—The International Journal of Tropical and Subtropical Horticulture* 61: 237–250. https://doi.org/10.1051/fruits:2006021

Ledin, R. B. 1959. “Cold Damage to Fruit Trees at the Sub-Tropical Experiment Station, Homestead.” *Proceedings of the Florida State Horticultural Society* 71: 341–344.

Lynch, S. J. 1940. “Observations on the January 1940 Cold Injury to Tropical and Subtropical Plants.” *Proceedings of the Florida State Horticultural Society* 53: 192–194.

Lynch, S. J. 1958. “The Effect of Cold on Lychees on the Calcareous Soils of Southern Florida 1957–58.” *Proceedings of the Florida State Horticultural Society* 71: 359–362.

Mahouachi, J., D. Fernández-Galván, and A. Gómez-Cadenas. 2013. “Abscisic Acid, Indole-3-Acetic Acid and Mineral-Nutrient Changes Induced by Drought and Salinity in Longan (*Dimocarpus longan* Lour.) Plants.” *Acta Physiologiae Plant* 35: 3137–3146 https://doi.org/10.1007/s11738-013-1347-1

Malo, S. E., P. G. Orth, and N. P. Brooks. 1977. “Effects of the 1977 Freeze on Avocados and Limes in South Florida.” *Proceedings of the Florida State Horticultural Society* 90: 247–251.

Marler, T. E. 1990. “Salinity affects growth and net gas exchange of carambola.” *HortScience* 25 (9): 1136. https://doi.org/10.21273/HORTSCI.25.9.1136d

Marler, T. E., and H. S. Clemente. 2006. “Papaya seedling growth response to wind and water deficit is additive.” *HortScience* 41 (1): 96–98. https://doi.org/10.21273/HORTSCI.41.1.96

Marler, T. E., and M. V. Mickelbart. 1998. “Drought, Leaf Gas Exchange, and Chlorophyll Fluorescence of Field-Grown Papaya.” *Journal of the American Society for Horticultural Science* 123 (4): 714–718. https://doi.org/10.21273/JASHS.123.4.714

Marler, T. E., and Y. Zozor. 1992. “Carambola Growth and Leaf Gas Exchange Responses to Seismic or Wind Stress.” *HortScience* 27 (8): 913–915. https://doi.org/10.21273/HORTSCI.27.8.913

Marler, T. E., and Y. Zozor. 1996. “Salinity influences photosynthetic characteristics, water relations, and foliar mineral composition of *Annona squamosa* L.” *Journal of the American Society for Horticultural Science* 121 (2): 243–248. https://doi.org/10.21273/JASHS.121.2.243

Menzel, C. M. 1985. “Guava: An Exotic Fruit with Potential in Queensland.” *Queensland Agricultural Journal* 111 (2): 93–98.

Menzel, C. M. 2001. “The Physiology of Growth and Cropping in Lychee.” *Acta Horticulturae* 558: 175–184. https://doi.org/10.17660/ActaHortic.2001.558.24

Menzel, C. M. 2002. *The Lychee Crop in Asia and the Pacific.* RAP Publication 2002/16. Food and Agriculture Organization of the United Nations and the Regional Office for Asia and the Pacific.

Mizrahi, Y. 2014. “Pitaia: uma nova fruta no mundo” [Vine-Cacti Pitayas: The New Crops of the World]. *Revista Brasileira de Fruticultura* 35 (1). https://doi.org/10.1590/0100-2945-452/13

Nakasone, H. Y., and R. E. Paull. 1998. *Tropical Fruits*. CAB International.

Nerd, A., Y. Sitrit, R. A. Kaushik, and Y. Mizrahi. 2002. “High summer temperatures inhibit flowering in vine pitaya crops (*Hylocereus* spp.).” *Scientia Horticulturae* 96 (1–4): 343–350. https://doi.org/10.1016/S0304-4238(02)00093-6

Nerd, A., N. Tel-Zur, and Y. Mizrahi. 2002. “11. Fruits of Vine and Columnar Cacti.” In *Cacti: Biology and Uses*, edited by P. S. Nobel. University of California Press.

Ngah, W. B. A., I. Ahmad, and A. Hassan. 1989. “Carambola Production, Processing, and Marketing in Malaysia.” *Proceedings of the Interamerican Society for Tropical Horticulture* 33: 30–43.

Nickum, M. T., J. H. Crane, B. Schaffer, and F. S. Davies. 2008. “Response of Mamey Sapote (*Pouteria sapota*) Trees to Flooding in a Very Gravelly Loam Soil in the Field.” *Proceedings of the Florida State Horticultural Society* 121: 14–18.

Nickum, M. T., J. H. Crane, B. Schaffer, and F. S. Davies. 2010. “Responses of Mamey Sapote (*Pouteria sapota*) Trees to Continuous Cyclical Flooding in Calcareous Soil.” *Scientia Horticulturae* 123 (3): 402–411. https://doi.org/10.1016/j.scienta.2009.09.021

Nickum, M. T., J. H. Crane, B. Schaffer, and F. S. Davies. 2011. “Leaf Net CO_2 Assimilation and Electrolyte Leakage and Alcohol Dehydrogenase Activity in Roots of Mamey Sapote (*Pouteria sapota*) Trees as Affected by Root Zone Oxygen Content.” *Proceedings of the Florida State Horticultural Society* 124: 18–22.

Nobel, P. S., and E. de la Barrera. 2004. “CO_2 Uptake by the Cultivated Hemiepiphytic Cactus, *Hylocereus* undatus." *Annals of Applied Biology* 144 (1): 1–8. https://doi.org/10.1111/j.1744-7348.2004.tb00310.x

Núnez-Elisea, R., B. Schaffer, J. B. Fisher, A. M. Colls, and J. H. Crane. 1999. "Influence of Flooding on Net CO_2 Assimilation, Growth and Stem Anatomy of Annona Species." *Annals of Botany* 84 (6): 771–780. https://doi.org/10.1006/anbo.1999.0977

Passos, V. M., N. O. Santana, F. C. Gama, J. G. Oliveira, R. A. Azevedo, and A. P. Vitória. 2005. "Growth and Ion Uptake in *Annona muricata* and *A. squamosa* Subjected to Salt Stress." *Biologia Plantarum* 49 (2): 285–288. https://doi.org/10.1007/s10535-005-5288-4

Paull, R. E., and O. Duarte, eds. 2010. "Litchi and Longan." In *Tropical Fruits*. Vol. 1. 2nd edition. Crop Production Science in Horticulture. CABI. https://doi.org/10.1079/9781845936723.0221

Paull, R. E., and O. Duarte, eds. 2012a. "American Fruit." In *Tropical Fruits*. Vol. 2. 2nd edition. Crop Production Science in Horticulture. CABI. https://doi.org/10.1079/9781845937898.0303

Paull, R. E., and O. Duarte, eds. 2012b. "Guava." In *Tropical Fruits*. Vol. 2. 2nd edition. Crop Production Science in Horticulture. CABI. https://doi.org/10.1079/9781845937898.0091

Paull, R. E., and O. Duarte, eds. 2012c. "Passion Fruit and Giant Passion Fruit." In *Tropical Fruits*. Vol. 2. 2nd edition. Crop Production Science in Horticulture. CABI. https://doi.org/10.1079/9781845937898.0161

Pingping, W., W. Chubin, and Z. Biyan. 2017. "Drought stress induces flowering and enhances carbohydrate accumulation in *Averrhoa carambola*." *Horticultural Plant Journal* 3 (2): 60–66. https://doi.org/10.1016/j.hpj.2017.07.008

Pinto, A. C. de Q., M. C. R. Cordeiro, and S. R. M. de Andrade, et al. 2005. *Annona Species*. International Centre for Underutilized Crops, University of Southampton.

Ramteke, V., and A. J. Sachin. 2016. "Salinity Influence in Tropical Fruit Crops." *Plant Archives* 16 (2): 505–509.

Ravi, I., M. Mayilvaganan, and M. M. Mustaffa. 2014. "Bananas grown in salt affected soils impair fruit development in susceptible cultivars." *The Andhra Agricultural Journal* 61 (3): 638–642.

Ravi, I., M. M. Vaganan, and M. M. Mustaffa. 2014. *Management of Drought and Salt Stresses in Banana*. Technical Folder No. 6. National Research Centre for Banana, Indian Council of Agricultural Research.

Rodrigues, B. R. A., R. C. dos Santos, S. Nietsche, M. O. Mercadante-Simões, I. R. G. da Cunha, and M. C. T. Pereira. 2016. "Determination of Cardinal Temperatures for Sugar Apple (*Annona squamosa* L.)." *Ciência e Agrotecnologia* 40 (2): 145–254. https://doi.org/10.1590/1413-70542016402039115

Rodriguez, G., B. Schaffer, A. I. Vargas, and C. Basso. 2014. "Effect of Flooding Duration and Portion of the Roots Submerged on Physiology, Growth and Survival of Papaya (*Carica papaya* L.)." *HortScience* 49: S293.

Rouse, R. E., and R. J. Knight, Jr. 1991. "Evaluation and Observations of Avocado Cultivars for Subtropical Climates." *Proceedings of the Florida State Horticultural Society* 104: 24–27.

Salapetch, S., D. W. Turner, and B. Bell. 1990. "The flowering of carambola (*Averrhoa carambola* L.) is more strongly influenced by cultivar and water stress than by diurnal temperature variation and photoperiod." *Scientia Horticulturae* 43 (1–2): 83–94. https://doi.org/10.1016/0304-4238(90)90039-H

Sanclemente, M. A., B. Schaffer, P. M. Gill, A. I. Vargas, and F. S. Davies. 2014. "Pruning after flooding hastens recovery of flood-stressed avocado (*Persea americana* Mill.) trees." *Scientia Horticulturae* 169: 27–35. https://doi.org/10.1016/j.scienta.2014.01.034

Santos, A. S., E. P. Amorim, C. F. Ferreira, and C. P. Pirovani. 2018. "Water Stress in *Musa* spp.: A Systematic Review." *PLOS One* 13 (12): e0208052. https://doi.org/10.1371/journal.pone.0208052

Saran, P. L., I. S. Solanki, and R. Choudhary. 2016. *Papaya: Biology, Cultivation, Production and Uses.* CRC Press. https://doi.org/10.1201/b18955

Schaffer, B. 1998. "Flooding Responses and Water-Use Efficiency of Subtropical and Tropical Fruit Trees in an Environmentally Sensitive Wetland." *Annals of Botany* 81 (4): 475–481.

Schaffer, B., F. S. Davies, and J. H. Crane. 2006. "Responses of Subtropical and Tropical Fruit Tree Flooding in Calcareous Soil." *HortScience*

41 (3): 549–555. https://doi.org/10.21273/HORTSCI.41.3.549

Schaffer, B., P. M. Gil, M. V. Mickelbart, and A. W. Whiley. 2013. “Ecophysiology.” In *The Avocado: Botany, Production and Uses*, edited by B. Schaffer, B. N. Wolstenholme, and A. W. Whiley. 2nd edition. CABI.

Schaffer, B., L. Urban, P. Lu, and A. W. Whiley. 2009. “Ecophysiology.” In *The Mango: Botany, Production and Uses*, edited by R. E Litz. 2nd edition. CABI. https://doi.org/10.1079/9781845934897.0170

Stern, R. A., I. Adato, M. Goren, D. Eisenstein, and S. Gazit. 1993. “Effects of Autumnal Water Stress on Litchi Flowering and Yield in Israel.” *Scientia Horticulturae* 54 (4): 295–302. https://doi.org/10.1016/0304-4238(93)90108-3

Stern, R. A., M. Meron, A. Naor, R. Wallach, B. Bravdo, and S. Gazit. 1998. “Effect of Fall Irrigation Level in 'Mauritius' and 'Floridian' Lychee on Soil and Plant Water Status, Flowering Intensity, and Yield.” *Journal of the American Society for Horticultural Science* 123 (1): 150–155.

Stover, R. H., and N. W. Simmonds. 1993. *Bananas.* Longman Scientific & Technical.

Thani, Q. A., B. Schaffer, G. Liu, A. I. Vargas, and J. H. Crane. 2016. “Chemical oxygen fertilization reduces stress and increases recovery and survival of flooded papaya (*Carica papaya* L.) plants.” *Scientia Horticulturae* 202: 173–183. https://doi.org/10.1016/j.scienta.2016.03.004

Thani, Q. A., A. I. Vargas, B. Schaffer, G. Liu, and J. H. Crane. 2016. “Responses of Papaya Plants in a Potting Medium in Containers to Flooding and Solid Oxygen Fertilization.” *Proceedings of the Florida State Horticultural Society* 129: 27–34.

Thomson, P. H. 1998. *Pitahaya: A Promising New Fruit Crop for Southern California*. Bonsall Publications.

USAID. 2019. *Feed the Future. Passion Fruit Production Manual*.

Wei, J., D. Liu, Y. Liu, and S. Wei. 2022. “Physiological analysis and transcriptome sequencing reveal the effects of salt stress on banana (*Musa acuminata* cv. BD) leaf.” *Frontiers in Plant Science* 13: 822838. https://doi.org/10.3389/fpls.2022.822838

Willadino, L., T. R. Camara, M. B. Ribeiro, D. O. J. do Amaral, F. Suassuna, and M.V. da Silva. 2016. “Mecanismos de tolerância à salinidade em bananeira: Aspectos fisiológicos, bioquímicos e moleculares” [Mechanisms of Tolerance to Salinity in Banana: Physiological, Biochemical and Molecular Aspects]. *Revista Brasileira de Fruticultura* 39 (2): e732. https://doi.org/10.1590/0100-29452017723

Witney, G., and M. L. Arpaia. 1991. “Tree Recovery After the December 1990 Freeze.” *California Avocado Society 1991 Yearbook* 75: 63–70.

Wolstenholme, B. N. 2013. “Ecology: Climate and Soils.” In *The Avocado: Botany, Production and Uses*, edited by B. Schaffer, B. N. Wolstenholme, and A. W. Whiley. 2nd edition. CABI. https://doi.org/10.1079/9781845937010.0086

Yamada, M., H. Fukamachi, and T. Hidaka. 1996. “Photosynthesis in Longan and Mango as Influenced by High Temperatures Under High Irradiance.” *Journal of the Japanese Society for Horticultural Science* 64 (4): 749–756. https://doi.org/10.2503/jjshs.64.749

Yamada, M., T. Hidaka, and H. Fukamachi. 1996. “Heat Tolerance in Leaves of Tropical Fruit Crops as Measured by Chlorophyll Fluorescence.” *Scientia Horticulturae* 67 (1–2): 39–48. https://doi.org/10.1016/S0304-4238(96)00931-4

Young, T. W. 1963. “The 1962 Freeze vs. the Florida Lychee Industry.” *Proceedings of the Florida State Horticultural Society* 71: 365–370.

Young, T. W., and J. C. Noonan. 1958. “Freeze Damage to Lychees.” *Proceedings of the Florida State Horticulture Society* 71: 300–304.

Tables

Table 1. Annona—sugar apple (*Annona squamosa*), guanábana (*A. muricata*), and atemoya (*A. cherimola* x *A. squamosa*).

Environmental factors	Crop information		
	Sugar apple	Guanábana	Atemoya
Optimum growing temperature range (°F)	75–86	68–86	65–86
Freeze damage range (°F) for mature trees	28–29	30–32	<28
Heat damage range (°F)	>100	>100	>100
Sensitivity to constant winds	Intolerant	Intolerant	Intolerant
Flood tolerance	Intolerant, rootstock dependent	Moderately tolerant	Intolerant, rootstock dependent
Plant and/or rootstock salinity tolerance	Sensitive to intolerant	Not reported	Not reported
Drought tolerance	Tolerant	Tolerant	Tolerant
Comments: More than a few days of temperatures below ~50°F result in chilling injury. Flood tolerance is moderately rootstock dependent. Atemoya is reported as drought-tolerant, but drought conditions may still result in leaf abscission and reduce growth and yields. Irrigation is common practice.			

Table 2. Avocado (*Persea americana*)—West Indian (WI), Guatemalan (G), and Mexican (M) ecotypes, WI-G hybrids, and G x M hybrids.

Environmental factors	Crop information				
	West Indian ecotypes	Guatemalan ecotypes	Mexican ecotype	West Indian x Guatemalan hybrids	Guatemalan x Mexican hybrids
Optimum growing temperature range (°F)	72–95	55–75	50–70	70–91	65–86
Freeze damage range (°F) for mature trees	25–30	21–25	18–25	24–30	20–27
Heat damage range (°F)	>100	>90	>90	>100	>100
Flood tolerance	Sensitive to intolerant	Sensitive to intolerant	Sensitive to intolerant	Sensitive to intolerant	Sensitive to intolerant
Plant and/or rootstock salinity tolerance	Most tolerant	Intermediate tolerance	Least tolerant	Varies	Varies
Drought tolerance	Moderately tolerant	Moderately tolerant	Moderately tolerant	Moderately tolerant	Moderately tolerant
Comments: West Indian ecotypes are the least cold-hardy type grown in Florida. Guatemalan ecotypes are more cold hardy and have only a few commercial cultivars. Mexican ecotypes are most cold hardy and have only a few cultivars. West Indian x Guatemalan (WI x G) hybrids have variable cold hardiness and are the most common of the cultivars grown in Florida. Guatemalan x Mexican hybrids are generally more cold hardy than WI x G, but most California hybrids have not been extensively tested in Florida. Sensitivity to constant winds is not reported for any of the ecotypes or hybrids. Flood tolerance is influenced by rootstock. Drought tolerance by ecotype is not compared. Irrigation is common practice. Rootstock affects salinity tolerance (WI>G>M).					

Table 3. Banana (*Musa* spp.)—fresh and cooking.

Environmental factors	Crop information for banana
Optimum growing temperature range (°F)	70–86
Freeze damage range (°F) for mature trees	28–32
Heat damage range (°F)	>99
Sensitivity to constant winds	Intolerant
Flood tolerance	Moderate tolerance to intolerant
Plant and/or rootstock salinity tolerance	Low tolerance to intolerant (no rootstocks)
Drought tolerance	Intolerant to moderately tolerant
Comments: Leaf emergence stops at ~61°F and all growth stops at ~50°F. Chilling injury occurs at or below ~52°F. Temperatures at or below ~61°F can cause fruit distortion, failure of the bunch to emerge from the pseudostem, and increased susceptibility to finger rots. Growth stops at 100°F–104°F. Wind: A small amount of leaf lamina tearing is beneficial for water relations (i.e., improved transpiration and CO_2 uptake) and photosynthesis. Too much tearing (shredding, tattering) is not beneficial. Winds greater than ~25 mph can cause plants to topple (uproot). Banana plants may withstand 48 hr of flooding with flowing water but only ~24 hr of stagnant water.	

Table 4. Carambola—starfruit (*Averrhoa carambola*).

Environmental factors	Crop information for carambola (starfruit)
Optimum growing temperature range (°F)	70–90
Freeze damage range (°F) for mature trees	27–32
Heat damage range (°F)	>100
Sensitivity to constant winds	Intolerant
Flood tolerance	Moderately tolerant to tolerant
Plant and/or rootstock salinity tolerance	Intolerant
Drought tolerance	Intolerant
Comments: Carambola trees can withstand ~14 days of continuous flooding and recover well once the soil drains. Drought can be used to trigger off-season bloom but may trigger leaf drop.	

Table 5. Dragonfruit—pitaya (*Selenicereus undatus*, *S. guatemalensis*, hybrids).

Environmental factors	Crop information for dragonfruit (pitaya)
Optimum growing temperature range (°F)	68–86
Freeze damage range (°F) for mature vines	<26–29
Heat damage range (°F)	>93–104
Sensitivity to constant winds	Moderately intolerant
Flood tolerance	Moderately tolerant to tolerant
Plant and/or rootstock salinity tolerance	Moderately tolerant
Drought tolerance	Moderately tolerant
Comments: Chilling injury results from long exposure to 41°F or below. Temperatures above ~92°F begin to cause physiological damage. Plant may tolerate ~1 week of flooding, but flood conditions may increase the potential for stem-root diseases. Constant or strong periodic winds can delay flowering of new vines, reduce flower intensity and fruit yield, and increase wind-scar.	

Table 6. Guava—guayaba (*Psidium guajava*).

Environmental factors	Crop information for guava
Optimum growing temperature range (°F)	66–82
Freeze damage range (°F) for mature trees	25–26
Heat damage range (°F)	>110–113
Sensitivity to constant winds	Moderately tolerant
Flood tolerance	Moderately tolerant
Plant and/or rootstock salinity tolerance	Moderately tolerant
Drought tolerance	Tolerant
Comments: Invasive plant status: Guava has been assessed by the UF/IFAS Invasive Plants Working Group as invasive and is not recommended by UF/IFAS for planting in south Florida; guava may be planted in central Florida but should be managed to prevent escape. Tree is tolerant to drought, but drought conditions reduce growth and fruit production. Tree is moderately tolerant to wet soil conditions, but susceptibility to root pathogens increases under constant wet soil conditions. Winds >10 mph distort growth and increase fruit scarring; trees benefit from wind protection.	

Table 7. Longan (*Dimocarpus longan*).

Environmental factors	Crop information for longan
Optimum growing temperature range (°F)	>60–92
Freeze damage range (°F) for mature trees	24–27
Heat damage range (°F)	>95
Sensitivity to constant winds	Moderately tolerant
Flood tolerance	Moderately tolerant
Plant and/or rootstock salinity tolerance	Moderately tolerant
Drought tolerance	Moderately tolerant
Comments: Low relative humidity (RH) and/or high temperatures may reduce fruit set and the number of female flowers. Fruit should be thinned when pea-sized. Overproduction may lead to tree decline.	

Table 8. Lychee (litchi) (*Litchi chinensis*).

Environmental factors	Crop information for lychee
Optimum growing temperature range (°F)	55–92
Freeze damage range (°F) for mature trees	21–28
Heat damage range (°F)	>95
Sensitivity to constant winds	Moderately tolerant
Flood tolerance	Moderately tolerant
Plant and/or rootstock salinity tolerance	Intolerant
Drought tolerance	Tolerant
Comments: Tree requires dormant period and exposure to chilling temperatures (i.e., ≤59°F) to flower well. Temperatures ≥68°F reduce chilling requirement. Low RH and/or high temperatures may reduce fruit set and the number of female flowers. Late season flowers may not set fruit and/or set fruit that develops properly.	

Table 9. Mamey sapote (*Pouteria sapota*).

Environmental factors	Crop information for mamey sapote
Optimum growing temperature range (°F)	68–90
Freeze damage range (°F) for mature trees	28–30
Heat damage range (°F)	No information
Sensitivity to constant winds	Moderately tolerant
Flood tolerance	Moderately tolerant
Plant and/or rootstock salinity tolerance	No information
Drought tolerance	Moderately intolerant
Comments: Tree may defoliate in response to drought, flooding, and cold/freeze.	

Table 10. Mango (*Mangifera indica*).

Environmental factors	Crop information for mango
Optimum growing temperature range (°F)	75–86
Freeze damage range (°F) for mature trees	25–28
Heat damage range (°F)	>104
Sensitivity to constant winds	Moderately intolerant
Flood tolerance	Moderately tolerant to tolerant
Plant and/or rootstock salinity tolerance	Intolerant to moderately tolerant
Drought tolerance	Tolerant
Comments: Tolerance to salinity is affected by rootstock, and typically those rootstocks are not used in Florida.	

Table 11. Papaya (*Carica papaya*).

Environmental factors	Crop information for papaya
Optimum growing temperature range (°F)	77–91
Freeze damage range (°F) for mature trees	<30
Heat damage range (°F)	>96
Sensitivity to constant winds	Intolerant, sensitive
Flood tolerance	Intolerant
Plant and/or rootstock salinity tolerance	Moderately tolerant
Drought tolerance	Intolerant
Comments: Tree needs at least 73°F for six months for normal flowering and fruit development. Papaya trees stop growing at and below 54ºF. Chilling temperatures at and below 61ºF will reduce growth and production.	

Table 12. Passionfruit (*Passiflora edulis* forms and hybrids).

Environmental factors	Crop information for passionfruit
Optimum growing temperature range (°F)	68–86
Freeze range (°F) for mature trees	<28–32
Heat damage range (°F)	>91
Sensitivity to constant winds	Intolerant, sensitive
Flood tolerance	Slightly tolerant to intolerant
Plant and/or rootstock salinity tolerance	Intolerant

Environmental factors	Crop information for passionfruit
Drought tolerance	Moderately tolerant
Comments: Tolerance to flooding is affected by passionfruit species, soil, climatic factors, and the presence of disease pathogens in the soil. Vines may tolerate about four days of drought; if more, then drought conditions will stop growth, flowering, and fruit set, and vines may drop flower buds, resulting in reduced yields. Heat damage may reduce or stop vine growth, cause flower bud or flower drop, and result in reduced production.	

Table 13. Annona citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Higuchi et al. (1998); Nakasone and Paull (1998); Pinto et al. (2005); Rodrigues et al. (2016)
Freeze range (°F)	Campbell et al. (1977); Lynch (1940); Nakasone and Paull (1998); Pinto et al. (2005)
Heat damage range (°F)	Higuchi et al. (1998); Yamada, Hidaka, et al. (1996)
Sensitivity to constant winds	Leal and Paul (2022); Nakasone and Paull (1998); Pinto et al. (2005)
Flood tolerance	Fu et al. (2012); Leal and Paul (2022); Nakasone and Paull (1998); Núnez-Elisea et al. (1999); Schaffer et al. (2006)
Salinity tolerance	Marler and Zozor (1996); Passos et al. (2005)
Drought tolerance	Pinto et al. (2005)

Table 14. Avocado citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Chao and Paull (2008); Dubrovina and Bautista (2014); Wolstenholme (2013)
Freeze damage range (°F)	Arpaia et al. (2012); Campbell et al. (1977); Hatton and Reeder (1963); Krezdorn (1970); Malo et al. (1977); Rouse and Knight (1991); Witney and Arpaia (1991)
Heat damage range (°F)	Wolstenholme (2013)
Sensitivity to constant winds	Schaffer et al. (2013)
Flood tolerance	Schaffer (1998); Schaffer et al. (2006); Schaffer et al. (2013); Sanclemente et al. (2014)
Salinity tolerance	Ebert (2000); Schaffer et al. (2013)
Drought tolerance	Schaffer et al. (2013)

Table 15. Banana citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Nakasone and Paull (1998); Stover and Simmonds (1993)
Freeze damage range (°F)	Campbell et al. (1977); Nakasone and Paull (1998); Stover and Simmonds (1993)
Heat damage range (°F)	Nakasone and Paull (1998); Stover and Simmonds (1993)
Sensitivity to constant winds	Nakasone and Paull (1998); Stover and Simmonds (1993)
Flood tolerance	Nakasone and Paull (1998); Stover and Simmonds (1993)
Salinity tolerance	Al Harthy et al. (2018); Ramteke and Sachin (2016); Wei et al. (2022); Junior et al. (2020); Willadino et al. (2016); Ravi, Mayilvaganan, et al. (2014); Ravi, Vaganan, et al. (2014)
Drought tolerance	Santos et al. (2018)

Table 16. Carambola citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	George et al. (2002); Ngah et al. (1989)
Freeze damage range (°F)	Campbell et al. (1985); Campbell et al. (1977); Lynch (1940)

Environmental factor	Citations
Heat damage range (°F)	George et al. (2002); Yamada, Hidaka, et al. (1996)
Sensitivity to constant winds	Goenaga (2017); Marler and Zozor (1992)
Flood tolerance	Ismail and Noor (1996); Joyner and Schaffer (1989); Schaffer (1998); Schaffer et al. (2006)
Salinity tolerance	Marler (1990)
Drought tolerance	Al-Yahyai et al. (2005); Ismail et al. (1994); Pingping et al. (2017); Salapetch et al. (1990)

Table 17. Dragonfruit citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Ben-Asher et al. (2006); Mizrahi (2014); Nobel and de la Barrera (2004)
Freeze damage range (°F)	Nerd, Tel-Zur, et al. (2002); Nobel and de la Barrera (2004)
Heat damage range (°F)	Nerd, Tel-Zur, et al. (2002); de Oliveira et al. (2020); Le Bellec et al. (2006); Nerd, Sitrit, et al. (2002); Nobel and de la Barrera (2004)
Sensitivity to constant winds	Thomson (1998)
Flood tolerance	Moderately tolerant ~1-wk. Personal communication with Chugn-Ruey Yen, June 7, 2022.
Salinity tolerance	de Sousa et al. (2021)
Drought tolerance	Nobel and de la Barrera (2004)

Table 18. Guava citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Kwee and Chong (1990); Menzel (1985); Paull and Duarte (2012b)
Freeze damage range (°F)	Campbell et al. (1977); Paull and Duarte (2012b)
Heat damage range (°F)	Menzel (1985); Paull and Duarte (2012b); Yamada, Hidaka, et al. (1996)
Sensitivity to constant winds	Menzel (1985); Paull and Duarte (2012b)
Flood tolerance	Menzel (1985)
Salinity tolerance	Menzel (1985); Paull and Duarte (2012b); Ramteke and Sachin (2016)
Drought tolerance	Menzel (1985); Paull and Duarte (2012b)

Table 19. Longan citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Groff (1921)
Freeze damage range (°F)	Campbell et al. (1977); Groff (1921); Groff (1943); Lynch (1940); Paull and Duarte (2010); Young (1963)
Heat damage range (°F)	Paull and Duarte (2010); Yamada, Fukamachi, et al. (1996); Yamada, Hidaka, et al. (1996)
Sensitivity to constant winds	J. H. Crane, personal communication
Flood tolerance	Crane et al. (2016)
Salinity tolerance	Mahouachi et al. (2013)
Drought tolerance	Mahouachi et al. (2013)

Table 20. Lychee citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Groff (1921); Groff (1943); Menzel (2001)

Environmental factor	Citations
Freeze damage range (°F)	Campbell et al. (1977); Groff (1921); Groff (1943); Lynch (1940); Lynch (1958); Young (1963); Young and Noonan (1958)
Heat damage range (°F)	Paull and Duarte (2010)
Sensitivity to constant winds	Groff (1943)
Flood tolerance	Menzel (2002)
Salinity tolerance	Menzel (2002)
Drought tolerance	Carr and Mezel (2014); Stern et al. (1993); Stern et al. (1998)

Table 21. Mamey sapote citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	J. H. Crane, personal communication
Freeze damage range (°F)	Campbell et al. (1977); Ledin (1959); Lynch (1940)
Heat damage range (°F)	No information
Sensitivity to constant winds	Paull and Duarte (2012a)
Flood tolerance	Nickum et al. (2008); Nickum et al. (2010); Nickum et al. (2011)
Salinity tolerance	No information
Drought tolerance	Paull and Duarte (2012a)

Table 22. Mango citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Schaffer et al. (2009)
Freeze damage at or below range (°F)	Campbell et al. (1977); Schaffer et al. (2009)
Heat damage range (°F)	Schaffer et al. (2009); Yamada, Hidaka, et al. (1996)
Sensitivity to constant winds	Schaffer et al. (2009)
Flood tolerance	Schaffer (1998); Schaffer et al. (2006); Schaffer et al. (2009)
Salinity tolerance	Schaffer et al. (2009); Ramteke and Sachin (2016); Ebert (2000)
Drought tolerance	Schaffer et al. (2009)

Table 23. Papaya citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Saran et al. (2016)
Freeze damage range (°F)	Campbell et al. (1977); Saran et al. (2016)
Heat damage at or above range (°F)	Saran et al. (2016)
Sensitivity to constant winds	Marler and Clemente (2006); Saran et al. (2016)
Flood tolerance	Rodriguez et al. (2014); Saran et al. (2016); Thani, Schaffer, et al. (2016); Thani, Vargas, et al. (2016)
Salinity tolerance	Ebert (2000); Saran et al. (2016)
Drought tolerance	Marler and Clemente (2006); Marler and Mickelbart (1998); Saran et al. (2016)

Table 24. Passionfruit citations.

Environmental factor	Citations
Optimum growing temperature range (°F)	Deshmukh et al. (2017); Paull and Duarte (2012c)
Freeze damage range (°F)	Campbell et al. (1977); Deshmukh et al. (2017)
Heat damage range (°F)	Campbell et al. (1977); Deshmukh et al. (2017)
Sensitivity to constant winds	Deshmukh et al. (2017); USAID (2019)

Environmental factor	Citations
Flood tolerance	Cervantes et al. (2015); Basso et al. (2019); Paull and Duarte (2012c)
Salinity tolerance	Ebert (2000)
Drought tolerance	Paull and Duarte (2012c)

[1] This document is HS1499, one of a series of the Department of Horticultural Sciences, UF/IFAS Extension. Original publication date February 2026. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

[2] Jonathan H. Crane, professor emeritus, tropical fruit crop specialist, and associate center director, Department of Horticultural Sciences, UF/IFAS Tropical Research and Education Center, Homestead, FL; Bruce Schaffer, professor, ecophysiology of subtropical and tropical horticultural crops, Department of Horticultural Sciences, UF/IFAS Tropical Research and Education Center, Homestead, FL; Young Gu Her, associate professor, hydrology and agricultural engineering, Department of Agricultural and Biological Engineering, UF/IFAS Tropical Research and Education Center, Homestead, FL; Haimanote Bayabil, associate professor, water resources, Department of Agricultural and Biological Engineering, UF/IFAS Tropical Research and Education Center, Homestead, FL; Jeff Wasielewski, commercial tropical fruit crops Extension agent II, UF/IFAS Extension Miami-Dade County, Homestead, FL; Clyde Fraisse, professor, agrometeorology, Department of Agricultural and Biological Engineering; UF/IFAS Extension, Gainesville, FL 32611.