2024 PEST MANAGEMENT STRATEGIC PLAN FOR CRAPEMYRTLE IN THE SOUTH

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EXECUTIVE SUMMARY

The 2024 Pest Management Strategic Plan (PMSP) *for* Crapemyrtle was developed to address key pest challenges and management strategies for crapemyrtle (*Lagerstroemia* spp.) in the Southern United States. This PMSP is the result of a virtual stakeholder meeting held on October 8, 2024, bringing together nursery growers, landscape professionals, university extension specialists, entomologists, plant pathologists, industry representatives, and regulatory agencies to identify the most pressing pest issues and establish research, regulatory, and educational priorities for sustainable pest management.

This PMSP covers the Southern IPM Region, including Alabama, Florida, Georgia, Louisiana, North Carolina, Tennessee, and Texas. The meeting was facilitated by researchers from Texas A&M University, University of Tennessee, Louisiana State University, University of Georgia, and North Carolina State University, with additional participation from representatives of the EPA, USDA Office of Pest Management Policy (OPMP), and the Southern IPM Center (SIPMC).

Economic and Regional Significance of Crapemyrtle

Crapemyrtle is a widely cultivated ornamental tree in the southeastern United States, valued for its low maintenance and vibrant floral displays. It is extensively used in residential and commercial landscapes, city streets, and parks. The wholesale and retail market value of crapemyrtle exceeds $70 million annually, making it an economically significant plant in the U.S. nursery and landscape industries. However, emerging invasive pests, such as crapemyrtle bark scale, threatens its sustainability, prompting the need for improved Integrated Pest Management (IPM) strategies.

Key Pests

Insects

Crapemyrtle aphid (*Sarucallis kahawaluokalani*)

Crapemyrtle bark scale (*Acanthococcus lagerstroemiae*)
Japanese beetle (*Popillia japonica*)
Whitefly (*Hemiptera: Aleyrodidae*)

Pathogens

Powdery mildew (*Erysiphe*)
Pseudocercospora leaf spot (*Pseudocercospora spp.*)
Sooty mold (general)

Weeds

Nutsedge (*Cyperus spp.*)
Pigweed (*Amaranthus spp.*)
Spotted spurge (*Euphorbia maculata*)

Critical Priorities

Education	Educate consumers and retail outlets about CMBS through campaigns, myth-busting, and available management options.
Education	Improve landscaper communication to consumers regarding CMBS issues and control methods.
Education	Develop educational materials on modes of action for pest control products, including how applications work, effectiveness, and highlights of new chemicals.
Regulatory	Clarify label distinctions between container-grown and field-grown crapemyrtles for pesticide applications.
Regulatory	Assess the regulatory status of neonicotinoids and their alternatives for crapemyrtle pest management.
Regulatory	Determine the regulatory status of fertilization and insecticide combinations for crapemyrtle production.
Research	Investigate insecticides other than neonicotinoids, including diamides, and assess their ecological effects on the surrounding environment.
Research	Develop CMBS-resistant varieties, ensuring pollinator protection and considering cold resistance in breeding efforts.

CROPS / SETTINGS

Crapemyrtle (*Lagerstroemia* spp.) is a versatile and low-maintenance flowering shrub or small to large tree that is commonly used in home landscapes, community developments, and as street trees. Multiple common names or spellings (e.g., crape myrtle, crepe myrtle, or crapemyrtle) existed when people refer to *Lagerstroemia* spp. However, the use of 'crapemyrtle' may avoid the confusion of *Lagerstroemia* (in the Lythraceae family) as a 'myrtle' plant (in the genus *Myrtus* and Myrtaceae family).

Crapemyrtle is native to East Asia but is now cultivated in many parts of the world. In terms of market demand, crapemyrtle is a popular plant among landscapers, gardeners, and homeowners, particularly in the southern United States. The plant is sold in various sizes and colors, with the larger and more mature specimens commanding a higher price.

Crapemyrtle is also used as a hedge, screen, or specimen plant. One of the most attractive features of crapemyrtle is the abundant summer color, which the plant blooms in a range of colors, including red, pink, lavender, and white. Its adaptability to a wide range of soil types and its tolerance for drought (after being established) make it a popular choice for landscaping. It is ideally suited for community plantings due to its long life and ease of management. However, the plant is also susceptible to several pests and diseases, such as scales, aphids, powdery mildew, and sooty mold, which can be managed through proper cultural practices and the use of appropriate pesticides.

Overall, crapemyrtle is a versatile and valuable crop with broad appeal in the ornamental plant industry. Its ease of cultivation, attractive appearance, and adaptability make it a desirable addition to any landscape or garden.

Vegetative architecture

Though more commonly adored for its floral blooms, as discussed below, there is much to be desired in the vegetative appearance of crapemyrtle. Though variable in size, depending on cultivar, crapemyrtles are densely branched and often multi-stemmed. Surrounding the stems, crapemyrtle has a unique bark that peels each year, revealing the new growth beneath. In some varieties, the revealed wood can appear reddish in tone, varying in color from the peeling bark. This aesthetic pairs well with the dense foliage surrounding the tops of these plants. The leaves grow from alternate nodes, each developing into a lanceolate shape that features entire margins and palmate venation. Leaf size can vary with the size of the plant; both shrubs and large tree varieties of crape myrtle are available. Additionally, there are common cultivars exhibiting fully darkened vegetative tissue. More specifically, the bark and leaves exhibit a dark purple color attributed to high anthocyanin accumulation. In some cases, this fades with maturity, but most sed varieties persist in color. Examples of darkened cultivars include the Ebony or Black Diamond™ series.

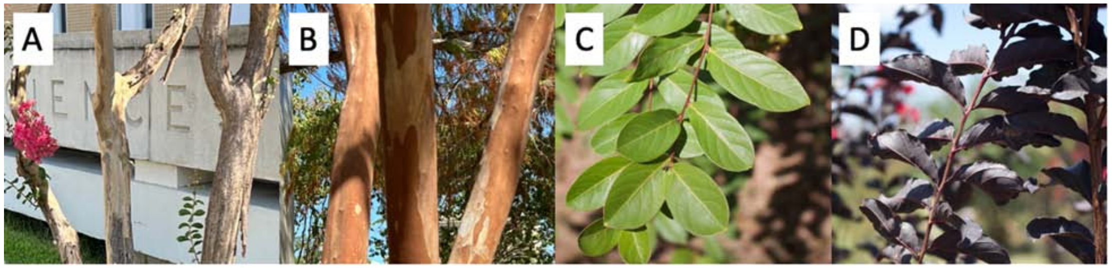


Figure 1: Common crapemyrtle vegetative structure traits. **A)** The most common bark color and an example of peeling bark. **B)** An example of the reddish bark available in some cultivars. **C)** The typical leaf pattern and shape found among crapemyrtle; imaged is 'Natchez'. **D)** An example of the darkened foliage; imaged is 'Ebony Embers'. Photos by: Hazen Keinath.

Flower architecture

Crapemyrtles feature large, colorful blooms displayed on large pinacle inflorescence structures. These structures emerge from the ends of new growth, usually beginning the second year after germination. Each individual bloom features a perfect, hypogynous flower ranging in the deep purple to red to white petal color range. At its base, the flower's calyx usually consists of six green sepals, deltoid in shape. The mainstay of crapemyrtle blooms are the unique crepe paper-like petals. Each corolla consists of five to seven spatulate petals crinkled toward their margin, each housed on a long stalk that extends past the sepals in length (Meerow, Ayala-Silva et al. 2015). Within the petals, many (up to 100) long stamens are clustered around the ovule. Each stamen typically consists of a yellow or light green anther held by a filament ranging in color from a yellow or light green to pink or red, depending on the cultivar. Especially among *L. indica* and its various hybrids, the flowers exhibit a heterantheric morphology, consisting of six elongated anthers that produce blue-green "real" pollen and a bundle of shorter, yellow anthers producing "feed" pollen for pollinators, such as bees (Nepi, Guarnieri et al. 2003). At its center, these flowers include a superior, globose ovary fitted with a long style that stands above the stamens. The pistil as a whole exhibits a light green color, paired with darker green tones as you approach the stigma. Additionally, it is common for the style to contain shades of pink or red along its length.

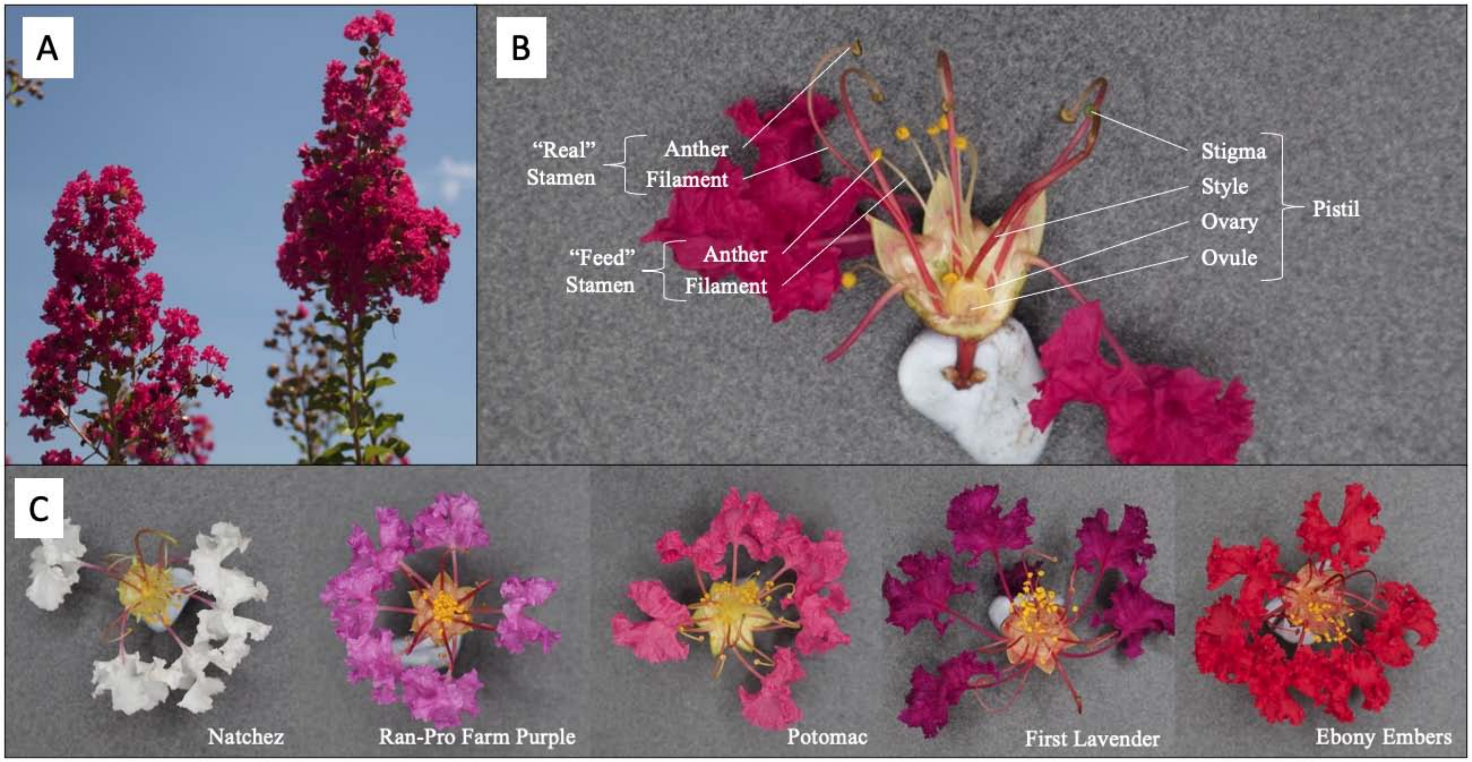


Figure 2: Crapemyrtle flower architecture and color range. **A)** Pinacle structures of crapemyrtle blooms. **B)** Cross-section of crapemyrtle, highlighting the reproductive organs ('Sioux' cultivar). **C)** Example flowers from various cultivars, as labeled. Photos by: Hazen Keinath.

Flower color

Most of the color of crapemyrtle blooms is the result of anthocyanin accumulation, or lack thereof, in the petals (Yu, Lian et al. 2021). Just like the crop of interest in this text, anthocyanins make up a family of closely related compounds, ranging on color from violet to red based on three major components: chemical structure, pH of the vacuole, and co-pigmentation effects with other flavonoids and metal ions (Alappat and Alappat 2020). Generally speaking, less chemically/metallically modified, lower pH anthocyanins exhibit red color, while the opposite produces violet or blue colors. Additionally, lesser amounts of anthocyanins in the petals can lead to lighter colors, such as pink or lavender, and a lack of anthocyanins can produce white varieties. Current crapemyrtle cultivars available cover almost every flower color produced by anthocyanins, with the exception of blue, which is rare amongst flowering species. Below are listed a few common examples of colors available and example cultivars (examples gathered from Crape Myrtle Trails).

Red: Dynamite, Arapaho, Ebony Embers

Purple: Twilight, Powhatan, Catawba

Lavender: Muskogee, Byers Hardy Lavender, Yuma

Pink: Tuscarora, Potomac, Miami

White: Natchez, Sarah's Favorite, Acoma

Even among the broad categories listed above, there is abundant variation in the specific colorations between crapemyrtle lines. Though there is an abundance of color options available, there are still many colors yet to be produced. The only anthocyanin-based petal color missing in the range is blue, which is notoriously rare among flowering plants (Dyer, Jentsch et al. 2020). In addition, there are yet to be any cultivars exhibiting non-anthocyanin colors, such as yellow and orange.

Crop growth stages

Dormancy

As a deciduous species, crapemyrtle will drop its leaves and enter a period of dormancy during the winter months where it stops growing and conserves energy for the upcoming growing season. The timing of leaf-drop can vary depending on factors such as weather patterns, temperature, soil moisture, and the specific species or cultivars of crapemyrtle planted. The process of leaf dropping can be accelerated when the crapemyrtle is under stress, such as drought or insect infestation.

Bud break and vegetative growth

In spring, when temperatures start to rise, the buds on Crapemyrtle branches begin to swell and open up, signaling the start of new growth. The onset of new growth can vary depending on the age and location of the plant, with more established and full-sun planted crapemyrtles generally waking up earlier than younger specimens. Sometimes, crapemyrtle can take a bit longer to push out foliage in late spring or early summer. During this stage, the crapemyrtle puts on new leaves, stems, and branches. It is important to provide adequate water and nutrients during this stage to support healthy growth.

Flowering and seed development

Crapemyrtle will produce an abundance of colorful blooms that can last for several months in the summer. The flowering time for crapemyrtle can vary depending on the specific cultivar and weather conditions in a given year. In general, flowering typically begins in late spring to late-summer, with peak bloom occurring from mid-July to mid-August. After the flowers have faded, the crapemyrtle will produce fruit in the form of small oval capsules that contain numerous winged seeds.

Senescence

As temperatures begin to cool in the fall, the crapemyrtle will begin to slow its growth and prepare for dormancy.

Growth habits

Crapemyrtle is one of the most versatile plants because of the various options in terms of plant and growth habits. Below are different crapemyrtle cultivars categorized in their heights.

Tall (20 ft. or more)

Example: Basham's Party Pink, Biloxi, Byers Standard Red, Byers Wonderful White, Carolina Beauty, Choctaw, Fantasy, Hardy Lavender, Kiowa, Miami, Muskogee, Natchez, Potomac, Red Rocket, Townhouse, Tuskegee, Tuscarora, Wichita.

Semi tall (10 to 20 ft.)

Example: Apalachee, Catawba, Centennial Spirit, Cherokee, Comanche, Conestoga, Lipan, Near East, Osage, Powhatan, Raspberry Sundae, Regal Red, Royal Velvet, Seminole, Sioux, Wm Toovey, Yuma.

Shrub (5 to 10 ft.)

Example: Acoma, Caddo, Hopi, Pecos, Prairie Lace, Tonto, Velma's Royal Delight, Zuni.

Dwarf (3 to 5 ft.)

Example: Baton Rouge, Bayou Rouge, Bourbon Street, Chica Pink, Chica Red, Chicasaw, Cordon Bleu, Delta Blush, Lafayette, New Orleans, Petite Embers, Petite Orchid, Petite Pinkie, Petite Plum, Petite Red, Pink Ruffles, Petite Snow, Pocomoke, Victor Deep.

Soil types

Crapemyrtle is a hardy plant that can tolerate adverse soil conditions, but it will grow and flower much better when planted in well-prepared soil. Crapemyrtle can adapt to a range of soil types, including clay, sand, and loam. It can also tolerate a range of soil pH levels, including alkaline and acidic soils. While crapemyrtle can grow in a variety of soil types, well-drained soil is preferred. Poorly drained soil creates an environment conducive to the development of root rot and the poor aeration of root zone compromises the overall health and vigor of the crapemyrtle (Knox 2006).

Crop Stages

Order	Crop Growth	Stage	Days After Emergence
1		Dormant	0
2	Sprout	Delayed Dormant (Bud Breaking)	
3	Vegetative	6- to 12-Inch Shoot	
4	Flowering	Bloom	

BACKGROUND

Crapemyrtle (*Lagerstroemia* spp.) is one of the most popular deciduous flowering trees in the United States, generating an estimated market value of up to $70 million per year (USDA 2001, USDA 2009, USDA 2014, USDA 2019). Its versatility as an ornamental plant and long blooming period makes it a widely used choice in landscape.

Crapemyrtle also plays an important role in the local ecosystem in the southeastern United States (Riddle and Mizell III 2016). While the flowers do not produce nectar, they offer a significant source of pollen to attract pollinators such as bees (Harris 1914, Kim, Graham et al. 1994). Studies have shown that crapemyrtle pollen is a major protein source with a nutritional makeup that is suitable for bee consumption (Nepi, Guarnieri et al. 2003). The extensive and heavy blooming of crapemyrtle during summer months (Pounders, Reed et al. 2006, Pounders, Blythe et al. 2010) make it a critical food source for pollinators, especially when many other flowering plants are not in bloom (Lau, Bryant et al. 2019). Due to its wide distribution, crapemyrtle provides excellent pollen sources for both native and non-native bees in the United States.

Crapemyrtle is relatively easy to maintain in the landscape with few severe diseases and insect complications. However, pest issues such as aphids, scale insects, Japanese beetle, and metallic flea beetles, and diseases such as powdery mildew and Cercospora leaf spot (caused by *Psedocercospora lythracearum*) may require proper management.

PRIORITIES

The top three education, regulatory, and research priorities were identified during the online workshop based on stakeholder input from growers, researchers, extension specialists, and industry representatives. These priorities reflect the most pressing pest management challenges facing crapemyrtle production and maintenance. Additionally, other unranked priorities were identified and included in this document to provide a comprehensive overview of current and emerging concerns.

In summary, workshop participants emphasized the need for targeted pest management strategies to reduce reliance on neonicotinoids, improve alternative control options, and enhance regulatory clarity for field-grown crapemyrtles. There is also a need for education on pest identification, sanitation practices, and application methods, along with research into resistant cultivars, effective treatment timing, and herbicide performance under variable environmental conditions. Overall, this document serves as a framework for guiding future research, regulatory decisions, and outreach efforts to support the crapemyrtle industry.

Category	Rank	Pest Type	Pest	Crop Stage	Priority	Outcome
Education	1	Insects	crapemyrtle bark scale		Educate consumers and retail outlets about CMBS through campaigns, myth-busting, and available management options.	
Education	2	Insects	crapemyrtle bark scale		Improve landscaper communication to consumers regarding CMBS issues and control methods.	
Education	3	Insects			Develop educational materials on modes of action for pest control products, including how applications work, effectiveness, and highlights of new chemicals.	
Education	No Rank				Develop standardized guidelines for tissue sample collection and analysis in field-grown crapemyrtles to enhance nutrient management and pest diagnosis.	
Education	No Rank				Educate growers and landscapers on the efficacy of mechanical control techniques.	
Education	No Rank				Provide ESA (Endangered Species Act) education for nurseries and landscape professionals.	
Education	No Rank	Insects	crapemyrtle bark scale		Education on the status of breeding efforts for CMBS-resistant cultivars.	
Education	No Rank	Insects	Whitefly		Provide education on whitefly jumping control strategies.	
Education	No Rank	Insects			Promote pollinator and beneficial insect protection in crapemyrtle pest management.	
Education	No Rank	Insects	crapemyrtle bark scale		Develop CMBS sanitation guidelines to prevent further spread, including the survival duration of CMBS on equipment and best practices for decontamination before re-entering fields.	
Education	No Rank	Weeds	Nutsedge		Develop guidelines for managing nutsedge without harming crapemyrtle trees.	
Education	No Rank	Weeds	Spotted spurge		Provide education on spotted spurge management.	
Regulatory	1	Insects			Clarify label distinctions between container-grown and field-grown crapemyrtles for pesticide applications.	
Regulatory	2	Insects			Assess the regulatory status of neonicotinoids and their alternatives for crapemyrtle pest management.	
Regulatory	3	Insects			Determine the regulatory status of fertilization and insecticide combinations for crapemyrtle production.	
Research	1	Insects			Investigate insecticides other than neonicotinoids, including diamides, and assess their ecological effects on the surrounding environment.	
Research	2	Insects	crapemyrtle bark scale		Develop CMBS-resistant varieties, ensuring pollinator protection and considering cold resistance in breeding efforts.	
Research	3	Weeds			Study herbicide effectiveness under heavy rainfall or frequent irrigation (extends beyond crapemyrtles).	
Research	No Rank				Conduct research on 'Rabbit Tracks' as an abiotic stress affecting crapemyrtle growth.	
Research	No Rank				Study the timing and behavior of pollinators visiting crapemyrtle in late summer to guide pollinator-safe pest management.	
Research	No Rank	Insects			Examine the efficacy of mechanical techniques for pest control in crapemyrtle production and maintenance.	
Research	No Rank	Insects	crapemyrtle bark scale		Identify a dormant oil formulation that can effectively penetrate and control adult CMBS.	
Research	No Rank	Insects	crapemyrtle bark scale		Improve CMBS control strategies, including chemical, biological, and cultural management techniques that provide better runoff protection and reduce reliance on neonicotinoids.	
Research	No Rank	Insects			Evaluate the efficacy and optimal application rates of insecticides (e.g., dinotefuran, imidacloprid) for field-grown crapemyrtles, comparing foliar, trunk, and granular treatments to refine dosage guidelines and improve pest control.	
Research	No Rank	Pathogens	Pseudocercospora leaf spot		Investigate control strategies for *pseudocercospora* on crapemyrtle.	
Research	No Rank	Weeds			Evaluate weed control costs associated with herbicide applications.	

WORKER ACTIVITIES

Production Practices	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Note
Fertilization (Nursery)		x			x								• Through the season for liquid in growing season • Not done in field grown
Pruning (Landscape)		x	x										• Or done on a needed basis. • Tip pruning: Trim branch tips as necessary to maintain the desired shape and size. • Water sprouts: Remove these as needed to prevent weak or excessive vertical growth. • Rubbing branches: Prune branches that rub against each other to prevent damage and improve overall tree structure.
Pruning (Nursery)													• Mainly done in dormant season, with light pruning after blooms to encourage healthy growth. • Sucker clean up on a as needed basis

Scouting (Nursery)													• Done on a weekly basis
Scouting (Landscape)													• Done on a weekly basis
Planting (Nursery)	x	x	x	x	x					x	x	x	• Begin planting after the last frost, typically from mid-April to May
Planting (Landscape)		x	x	x						x	x	x	• November to December is ideal, but planting can be done year-round if necessary.
Irrigation (Nursery)													• Irrigation frequency: Water as needed, increasing to twice daily during hot and dry seasons. • Methods: overhead irrigation or spray stakes for containers, and drip lines for field plants. • Fertigation and pesticides: Deliver nutrients and pesticides through the irrigation system as required.
Irrigation (Landscape)													• Upon installation: Water daily, especially for summer installations. • During establishment: Water weekly, adjusting frequency based on seasonal needs. • General maintenance: Preferably water 2-3 times a week, but adjust as necessary.
Propagation (Nursery)						x	x	x	x	x			• Some nursery contracted out propagation

PRODUCTION PRACTICES

Crapemyrtle is a popular and versatile ornamental plant known for its vibrant flowers, wide range of color options, attractive bark features, and ability to thrive in various landscape settings. With its wide range of cultivars and adaptability to different regions, crapemyrtle has become a staple in gardens, parks, and residential and commercial landscapes.

To meet the market demand for crapemyrtle, the nursery industry utilizes field production and container production to produce crapemyrtle suitable for different landscape applications. Crapemyrtle plants are available in various sizes, ranging from small "liners'' or transplants to large caliper trees of 6 feet and larger. Smaller plants are commonly produced and sold in trays or containers, while larger trees are mechanically harvested as bareroot or balled and burlapped.

Field production involves growing crapemyrtle trees in the ground, typically in dedicated production fields. This method allows for the cultivation of larger specimens but requires specific management considerations for harvesting, transportation, and storage. However, notable issues regarding field production include the potential loss of field soil and root mass during the harvesting process for balled and burlapped plants.

On the other hand, container production involves growing crapemyrtle in pots or containers, providing flexibility in terms of space, mobility, and controlled environments. Container-grown crapemyrtle trees are more popular among retail nurseries, landscape professionals, and homeowners seeking smaller-sized trees for immediate impact. However, container production is limited when it comes to producing large caliper trees due to the maximum available container size, typically up to 500 gallons (Braman, Chappell et al. 2015).

Both field production and container production have their unique considerations and techniques, which are implemented by nursery professionals to ensure the successful growth, health, and market readiness of crapemyrtle trees. From site selection and soil preparation to propagation, irrigation, fertilization, pest management, and pruning, a comprehensive understanding of production practices is crucial for producing high-quality crapemyrtle specimens. In this section, the key production practices involved in both field-grown and container-grown production of crapemyrtle are outlined to provide valuable insights that contribute to the successful cultivation of crapemyrtle, enriching outdoor spaces with its beauty and charm.

Field Production

Site selection and soil preparation

Crapemyrtle thrives in sunny locations, making it essential to choose a bright and sunny spot for planting. Lack of sunlight can cause reduced flowering (Wade and Williams-Woodward, 2009), and cultivars that are known for their dark foliage tend to have greener foliage under a less sun conditions. The favorable growing c a great option for difficult locations that are hot and dry, where many other ornamental plants struggle to grow. When planting, spacing is a crucial factor to consider as some cultivars can grow over 20 feet tall, with a canopy spread between 5 to 20 feet (Niemiera, 2018). Limited planting space will lead to excessive pruning when the plant reaches its mature form.

As a woody ornamental, crapemyrtles are adaptable to various soil conditions and thus well suited for urban areas and even more challenging soils. Crapemyrtles grow best in soil that is heavy loan to clay texture with a pH between 5.0 to 6.5 (Egolf, 1987). While crapemyrtles can tolerate poor soils, the ideal soil should be nutrient-rich and well-drained, as poor soil can hinder growth and development. Proper preparation can ensure that the plant will have access to the necessary nutrients and water it needs to thrive. A soil test may be conducted to assess various soil parameters, including pH level, organic matter content, nutrient levels (such as nitrogen, phosphorus, and potassium), micronutrient levels, and soil texture (proportions of sand, silt, and clay). Based on the findings, targeted soil amendments and fertilization can be done to optimize soil conditions for healthy crapemyrtle growth.

In nursery productions, additional factors such as operation space (turning radius for farming vehicles), topography (slope), and access to irrigation water need to be considered for site selection. A proper design of the planting rows and establishment of grassed waterways and buffer strips are effective in reducing soil losses and water runoff. Contour buffer strips of permanent, herbaceous vegetation should be established on sloping cropland and be at least 15 feet (4.6 m) wide to meet the conservation standards by USDA (USDA, 2014b).

Planting

Before planting, it is important to prepare the tree by removing any damaged or broken branches and roots. Digging the hole should be done at a depth that is slightly larger than the root ball. When planting, the root ball should be placed in the hole and back-filled with soil. It is important to avoid planting the tree too deep (no deeper than it originally grew in the container or field), as this can lead to poor drainage and hinder growth.

As an essential step in the planting process, watering is recommended for newly set transplants within 24 hours after planting to help firm soil around roots and eliminate air pockets (Braman et al., 2015). Newly planted trees need frequent watering to help establish roots and encourage growth. It is important to water thoroughly and consistently, ensuring the soil remains moist but not overly saturated.

Watering

Proper watering promotes the health and growth of crapemyrtle trees, and the watering requirements can vary depending on the growth stage and planting situation. Watering crapemyrtle at the base of the plant, not on the foliage, prevents the spread of foliar diseases. Additionally, watering in the morning or evening when the temperatures are cooler helps to reduce evaporation and water loss. Early morning (before 10 am) or late afternoon/evening (after 4 pm) are ideal for watering, as it allows sufficient time for foliage to dry before nightfall.

For newly planted crapemyrtle, it is important to water frequently in the first few weeks to help the tree establish roots. Watering should be done deeply, at least once or twice a week, depending on the weather conditions. A good rule of thumb is to water until the soil is moist to a depth of at least six inches. As the tree becomes established, watering frequency can be gradually reduced.

Established crapemyrtle trees in the landscape typically have deep root systems and can tolerate periods of drought without needing additional watering. They can often rely on natural rainfall to provide enough moisture, unless experiencing extended periods of drought. In such cases, supplemental watering may be necessary to prevent stress on the tree and enhance flowering (Wade and Williams-Woodward, 2009). It's important to monitor soil moisture levels and only water when the soil is dry to a depth of a few inches. Overwatering can be detrimental to the tree's health and may lead to root rot.

Fertilizing

Crapemyrtle, once established, generally has low fertility requirements but can benefit from regular fertilization to promote lush growth and abundant blooming. Conducting a soil test is recommended to assess important soil parameters such as pH and nutrient levels, enabling precise fertilizer recommendations. Following a proper fertilization regimen optimizes plant growth while minimizing the risk of groundwater pollution through reduced runoff and leaching of excess nutrients. Based on the soil test results, it is advisable to incorporate lime, superphosphate, and other nutrients before planting to adjust pH and improve the soil's nutritional balance. Crapemyrtle trees respond favorably to slightly acidic soil (pH 6.0-6.5) and general-purpose garden fertilizers can be used when needed or based on soil test. Alternatively, organic fertilizers like bone meal or rock phosphate can also be used to supplement nutrient needs.

Fertilizers are available in various forms, such as powder, granular, or liquid, and can be applied through different methods, such as broadcasting and placement of solid fertilizers, and fertigation using liquid fertilizers. Broadcasting involves the uniform distribution of fertilizers across the entire field either through basal application or top dressing. On the other hand, placement refers to the deliberate positioning of fertilizers at specific locations within the field. Broadcasting can be used prior to planting to adjust the overall nutrient balance of the soil, but it also promotes weed growth. Compared to broadcasting, placement is recommended for applying small amount of fertilizer, and it can be used to avoid weed pressure and lower nutrient runoff. For applying liquid (or soluble) fertilizers, fertigation is usually used, which the fertilizers are applied through irrigation water.

In the nursery production settings, an initial application of 50 lbs per acre nitrogen (N) to 6-to-8-inch soil can suffice the growing needs of woody plants such as crapemyrtle while minimizing nutrient runoff. In subsequent years, rather than broadcasting the fertilizer at the initial rate, the N fertilizer should be placed within the root zone as a side dress at the rate of 0.25 to 0.5 oz. N per plant (Smith, 2014). Alternatively, controlled-release fertilizer has also been developed for field application, allowing a single application to last the growing season.

During crapemyrtle container production, most growers in general incorporate controlled-release fertilizers (CRFs) in the substrate to provide necessary nutrients for plants to establish its root system and support new growth. Hence when transplanting a new crapemyrtle tree in the landscape, mixing fertilizers such as CRFs into the soil might not be necessary, or be handled as needed according to a soil test. In the landscape, crapemyrtles are generally very vigorous growing plants, but when growing in poor soil conditions might require occasional applications. For established crapemyrtle trees, fertilization might be performed as needed during the growing season, typically in spring to early summer when the tree is actively producing new growth. Fertilization in late summer should be avoided as it will interfere with the plants' ability to harden off in the fall. Established crapemyrtle trees in landscape may not require fertilization if they are growing in nutrient-rich soil and receive regular rainfall, as they may be able to obtain the necessary nutrients naturally. Monitoring the tree's growth and health can help determine if supplemental fertilization is necessary.

Propagation

Crapemyrtle can be propagated using various methods, including stem cuttings, root cuttings, or seeds. The most commonly used method is through semi-hardwood cuttings taken during late spring or early summer. In the southern US, the propagation rates of crapemyrtle through cuttings drop quickly by September. In northern states such as Michigan, the cutting propagation success starts dropping as early as July or August. Cuttings should measure three to six inches in length and have three to four nodes. It is advisable to remove the leaves from the lower half of the cutting, leaving a few leaves at the top. While crapemyrtle cuttings can root without hormones, rooting powder or solution can enhance rooting success and speed up the process. Once prepared, the cuttings should be inserted into a well-draining rooting medium and kept in a moist and shaded environment.

Root development usually occurs within three to six weeks while rooting success in cuttings varies across different times of the year. Cuttings taken during late spring to early summer typically exhibit rooting within three to five weeks, indicating this period as optimal for propagation efforts. Conversely, cuttings obtained in early spring show a notably lower rooting success rate. Additionally, cuttings derived from flowering plants or those taken in late summer are less likely to root effectively. Therefore, for optimal results in crapemyrtle cutting propagation, it is advisable to select cuttings during late spring to early summer.

Propagation by dormant cuttings has been used as a viable method in nursery production. Rooting success will be lower using this method, but it allows growers to continue production during slower seasons and increase production volume. 4-to-6-inch cuttings (approximately the diameter of a pencil) can be prepared and treated with a moderate IBA concentration before placing into a warm greenhouse with enough mist to prevent dehydration. The cuttings can be nicked or scarred on the basal end helps with IBA uptake and promoted callas growth.

For propagating crapemyrtle from seeds, collect mature seeds from fruit pods in the fall and sow them in a well-draining potting mix. Keep the soil consistently moist and warm, and seedlings should emerge within a few weeks. Whether using cuttings or seeds, it is crucial to maintain soil moisture and provide shade to prevent drying. Once the new plants have established roots, they can be transplanted to their permanent location in the landscape, preferably during dormant seasons such as winter (Wade and Williams-Woodward, 2009).

It is important to note that propagation practices can vary among different growers and nurseries. The decision on leaf removal during propagation often depends on balancing the need for photosynthesis and the need to reduce transpiration and conserve moisture. In the industry settings, the labor cost for certain propagation practices should also be taken into consideration. For example, Propagation by seed is never used for nursery production. Most commercial production is through asexual propagation. Seed propagation is useful in breeding programs to obtain new traits. Those seedlings of interest are asexually propagated. Commercial nurseries also seldom propagate crapemyrtles by root suckers.

Pruning

Crapemyrtle is known as a low-maintenance plant with little or no need for pruning when appropriate cultivar and correct placing were implemented. If necessary, pruning can be done for different purposes, such as promoting shape, thinning the tree, and maintaining size. While pruning is not essential for promoting flowering, it is known that proper pruning can lead to new vegetative growth that produce denser flower clusters (Gilman and Black, 2005) and higher number of flowers (Dihingia and Saud, 2016). For some cultivars, pruning to remove spent flower blossoms or the developing seed heads can stimulate new growth as well as more rounds of flower display (Gilman and Black, 2005; Wade and Williams-Woodward, 2009). However, over-pruning and incorrect pruning practices may damage the tree and produce undesirable plant architecture (Polomski and Shaughnessy, 2006).

Pruning is preferably done during the dormant season for crapemyrtle, typically in late winter or early spring, to avoid interfering with the blooming season. Since crapemyrtle produce flowers on new growth, pruning during the growing season can lead to loss of flower buds (Wade and Williams-Woodward, 2009). Pruning should be avoided in the fall, especially near the first frost, since it prevents plants going into full dormancy, leading to loss of cold hardiness of the crapemyrtle (Hayns et al., 1991).

Depending on the intended purpose, pruning can be done at early stages in the crapemyrtle's development. For example, when pruning for tree form, the focus is on removing lower branches to create a clear trunk and a well-defined canopy. The main stem should be trained to grow straight and tall, while any lateral branches should be pruned back to encourage upward growth. The ideal tree form for crapemyrtle is a single-trunk or multi-stemmed tree with a rounded or vase-shaped canopy. Removing lower branches allows for better air circulation and reduces the risk of disease and insect infestations. It also helps to create a cleaner, more aesthetically pleasing look.

On the other hand, when pruning for a shrub form, the focus is on creating a full and bushy plant with multiple stems. This can be achieved by leaving the lower branches intact and pruning the upper branches to promote branching and fuller growth. The shrub form is also a suitable option for smaller cultivars or for those grown in containers. Regardless of the plant form (single-, multi-trunk, or shrub), it is helpful to periodically remove suckers as a part of maintenance for mature crapemyrtle in the landscape. Suckers are unwanted shoots that grow from the roots and base of the tree. Removing these suckers ensures that the crapemyrtle focuses its energy on growing upward instead of outward.

Dormant pruning of the plant to 3-4 inches above the soil has been shown to be effective in incorporating crapemyrtles into smaller garden landscapes, or to encourage flowering at a lower height. Such a method is particularly beneficial when the landscape design requires smaller flowering shrubs, ensuring that the crapemyrtles remain proportionate to the garden's scale. Dwarf and semi-dwarf varieties of crapemyrtle are especially responsive to this type of practice, producing lush, manageable growth suited to compact spaces.

When it comes to maintaining crapemyrtle in the landscape, there are several pruning practices that were commonly used, including tipping, pollarding, and topping (Knox and Gilman, 2010). Tipping (also known as 'tip pruning', 'rounding over', or 'pencil pruning') is considered light pruning where only smaller-diameter branches on the outer edge of the canopy were removed (Figure 3). 'Tipping' practice can thin out the canopy by removing unwanted or dead branches with empty seed pods from the previous season while retaining the nature form of the crapemyrtle. However, tipping is very time consuming, thus it may be leading to the prevalence of more aggressive pruning practices such as pollarding and topping.

Pollarding and topping, on the other hand, are considered 'hard pruning,' where larger-diameter branches are removed. Pollarding is an annual pruning technique that involves making an initial cut on a multi-year-old branch. Subsequently, all sprouts that emerge each year are trimmed back to the original cutting area, creating a 'pollard head.' (Figure 3) Over time, the wound wood around the cut area swells, forming the pollard head storing significant energy for sprouting in the following season. Pollarding is typically done to confine plants to a specific size indefinitely, allowing crapemyrtle to regrow and maintain the same tree form each year.

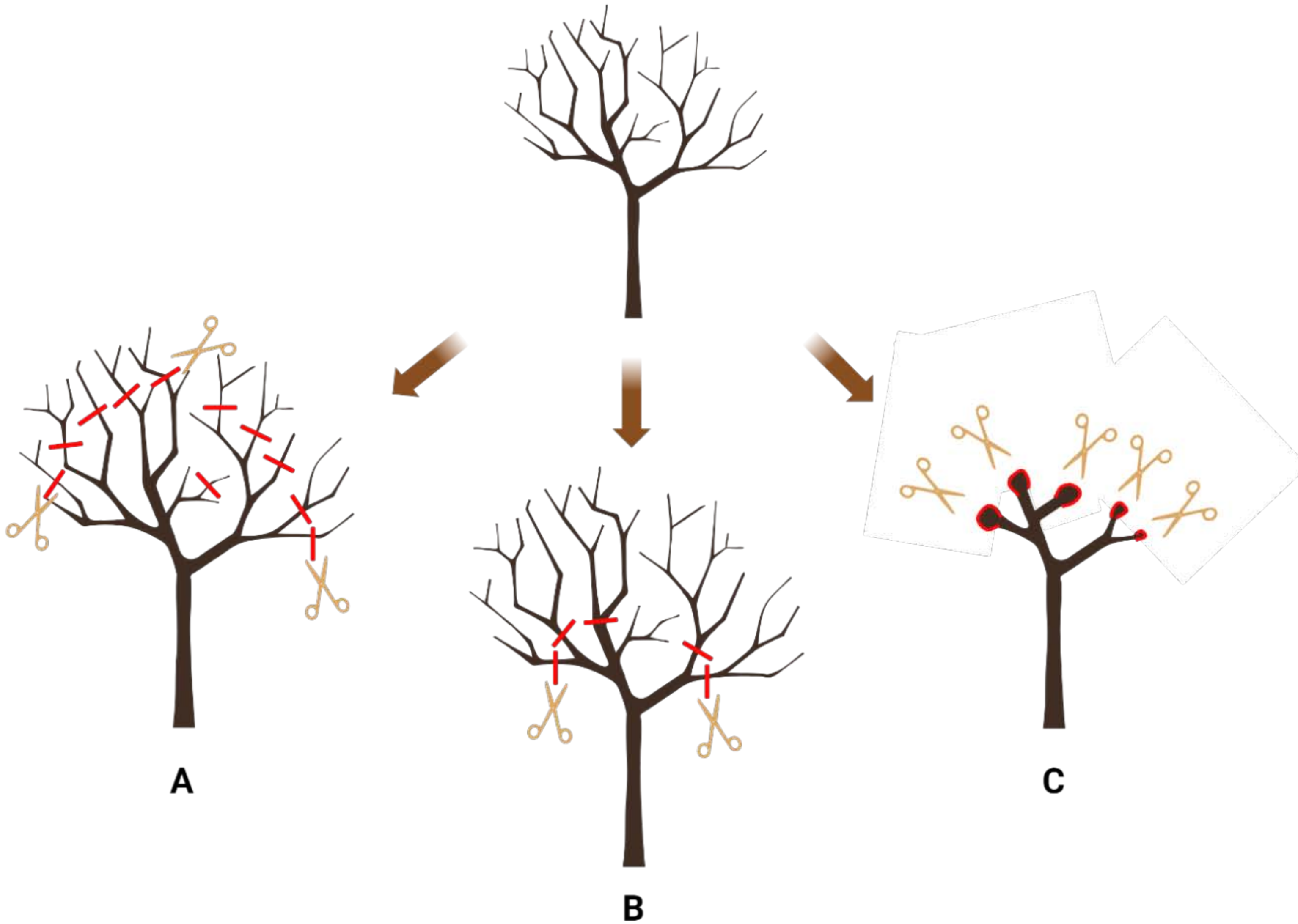


Figure 3: Three different pruning methods for crapemyrtle include: (A) Tipping, where only smaller-diameter branches on the outer edge of the canopy are removed; (B) Topping, where large-diameter branches are cut; and (C) Pollarding, where crapemyrtles are trimmed back to the same cutting area each year, creating a bulbous growth referred to as a 'pollarding head.'

Similar to pollarding, topping (also known as heading, stubbing, rounding, or dehorning) removes large-diameter branches, but the cuts were not made to the original cutting area, thus no 'pollard head' is formed (Figure 3). The topping method results in the shortening of all branches, hence, can also be used to restrict the size of a crapemyrtle. Compared to other selective pruning methods, topping is the least time-consuming method, however, study has shown that topping creates unstable branching structure and decaying or dead branches in the canopy (Gilman and Knox, 2005).

It is generally advised to avoid over-pruning crapemyrtle, as it may be unnecessary and result in an unappealing appearance, particularly in winter and if the natural form of the tree is desired. The practice of 'hard pruning' such as topping can have negative effects on the health of the crapemyrtle, potentially leading to pest and disease issues (Appleton et al., 2009). While it is true that crapemyrtle flowers only on new growth each season, excessive pruning to remove empty seedheads from the previous season is unnecessary, as they will naturally drop when new growth emerges.

Container Production

Selecting Containers

Selecting the right container for crapemyrtle involves considering factors including the physical properties of the container (e.g., size, material, functionality, and drainage) as well as the planting time frame. Growing crapemyrtle in containers restricts and slows down their growth, which is desirable if a miniature-sized plant is desired due to limited space. Crapemyrtle can also be grown as a bonsai tree. However, it's important to consider the mature plant size of the crapemyrtle, which varies greatly between different species or cultivars. Certain species of crapemyrtle, such as *L. speciosa*, are fast-growing plants that can reach up to 30 to 60 feet in height and approximately 30 to 40 feet in width (Gilman, Watson et al. 2019). Therefore, the container needs to provide ample room for the root system and accommodate the size and growth habit of the plant. An overgrown crapemyrtle in a container would easily topple over, especially when placed outdoors.

The effects of container size have a significant impact on the overall plant growth (NeSmith and Duval 1998). Moreover, the length of time the plant is likely to be spent in the container should be considered, as the transplanting timing affects greatly the vegetative growth on the finished plant (Knight, Eakes et al. 1993). In general, plants grown in larger containers have greater plant leaf area, and shoot and root biomass (Cantliffe 1993). Therefore, when the goal is to encourage growth, it is necessary to transplant crapemyrtles into larger containers once the plants reach their maximum growth potential in the original container. To transplant small plants or liners (containers < 8 inches in diameter) into larger containers, it is recommended to choose containers that are 1 to 2 inches wider than the current root ball. For transferring larger plants (containers > 10 inches in diameter), choosing 2-inches to 3-inches wider than the plant's root ball is ideal (Moore and Bradley 2018).

Most crapemyrtle sold by the nursery are planted in plastic containers. Plastic containers are lightweight, durable, and easy to handle, making them a practical choice for long-term use. Retail garden centers generally offer a variety of container sizes including trade #1 (2.5L), 2 gallon (g), 3g, 5g, 7g, 10g, and 15g, ranging from 15.24 to 44.45 cm (6–17.5 in) in diameter, allowing flexibility in choosing the appropriate container for different stages of plant growth. According to a recent survey, the three most popular sizes for crapemyrtles are 15 g, 30 g, and 45 g (Marwah, Zhang et al. 2021). For nurseries, the largest volume of units of crapemyrtles sold are 2 and 3g. While 1-gallon size provides the lowest price point, consumers are looking for a balance between cost-effectiveness and plant size during their purchase.

Plastic containers also retain moisture better than clay pots, which can be advantageous in hot and dry climates (Moore and Bradley 2018). There are also plastic air-pruned containers that promote a more fibrous root system, which greatly affects a plant's health and future establishments (Cooley 2013). Additionally, cupric hydroxide-treated (product trade name: SpinOut™) containers were found to be effective in controlling root circling and deflection when growing crapemyrtle, with no observed negative symptoms (Beeson Jr and Newton 1992).

While rarely used in commercial production settings, there are other container types utilizing different materials such as clay, wood, and fabric, available for consumers. Clay and wood containers provide better breathability for the roots as they allow air exchange through the container walls, preventing root suffocation and promoting overall plant health. They also have an aesthetic appeal that enhances the visual appeal of the landscape. However, clay pots are heavier and more prone to breakage compared to other materials. On the other hand, wood containers, such as cedar or redwood, provide natural durability (up to ten years) and add a rustic look to the landscape (Moore and Bradley 2018).

Fabric containers, known as grow-bags, are lightweight, portable (foldable), and offer excellent drainage. Fabric container is a hybrid form of production system between field and container production, as the container can be used above ground (similar to other types of container), or buried under soil, leaving only the top inch of the fabric exposed above ground (Gilman, Knox et al. 1994). Grow-bag confines plant root within its porous fabric barrier, leading to the effects of root pruning and root branching. However, a study compared Natchez crapemyrtle transplanted from field and grow-bag and found mostly equivalent plant performance in these two productions (Tilt, Gilliam et al. 1992). Nevertheless, fabric containers offer several potential benefits over traditional field production. They enable plants to retain a greater portion of their roots during transplanting, which reduces stress on the plant. Furthermore, fabric containers simplify the logistics of nursery operations, including the shipping of bags to the nursery. They also contribute to a reduction in the shipping weight of the finished plants, making the transportation process more efficient.

The decision to utilize alternative production systems, such as grow-bags, may depend on the field soil conditions, which determine the ease of traditional field harvesting. Regardless of the material, it is crucial to ensure that containers have sufficient drainage or can be modified to allow excess water to escape. Adequate drainage prevents waterlogging, which can lead to root rot and other plant health issues.

Substrates

The media used to grow container plants is generally referred to as 'substrate', 'potting mix', and 'growing media', and they do not usually contain field soil. Field soils are generally too heavy and do not have enough pore space and drainage when placed inside container, thus unfit for container plant production. For cultivating container-grown crapemyrtle, proper substrate preparation includes the considerations of the substrate's physical properties [e.g, total porosity, container capacity (i.e., water holding capacity), and air-filled porosity] and chemical properties (e.g., pH, electrical conductivity, and nutrient levels).

The substrate composition should have the ability to retain moisture while promoting proper drainage to prevent waterlogged conditions and provide adequate aeration for the roots. A typical substrate mixture for container-grown crapemyrtle includes a combination of organic and inorganic components such as peat moss or coconut coir for moisture retention, perlite or vermiculite for improved aeration, and pine bark or composted pine fines for structure and nutrient availability.

For outdoor container nurseries where large amounts of substrates are required, the input cost and availability of raw materials are also important factors to be considered. The most common substrate adopted by the U.S. nurseries include a mixture of pine bark, sphagnum peat moss, and sand, at varying ratio. Aged pine park (particle size ranging from 0.5 to 16 mm, with up to 30% under 0.5 mm) is generally preferred compared to fresh pine bark due to the enhanced water holding capacity (Bilderback 2017). In general, growers use a recipe of 80% to 100% aged pine bark, with addition of sand or peat moss to make up the rest (Braman, Chappell et al. 2015, Bilderback 2017). Sometimes sand and soil are added to increase the weight, which reduces container tip-over, but can also introduce pathogens. However, pine bark, especially when aged, is limited and time-consuming to acquire. Therefore, alternative materials to pine bark have been increasingly studied and used to lower the production cost.

Most alternative substrates are organic wastes such as shredded coconut husks (coir), rice hulls, peanut hulls, pecan shells, and other composted wastes (e.g., yard wastes, animal wastes, and hardwood bark). These organic matters need to be fully composted before using since unstable organic material tend to decompose and losing volume rapidly.

High wood-fiber content substrates such as clean chip residual (CCR), ground pine chips (PC), and WholeTree (WT) has been evaluated for their potential replacement for pine bark (PB) in crapemyrtle container production. Boyer, Gilliam et al. (2009) used CCR at varying sizes [screening size up to 3.18 cm (1.25 inch)] to grow 'Hopi' and 'Natchez' crapemyrtles in #1 container and found no difference in performance between the plants grown in CCR and PB. Marble, Fain et al. (2012) also demonstrated that both CCR and WT could be used to produce equivalent marketable crapemyrtle compared to PB. On the other hand, Wright, Browder et al. (2006) showed that crapemyrtle were larger when grown in PB compared to PC, which is attributed by the lower nutrient availability in PC. These studies suggest that alternative wood-based substrates could potentially replace the declining supply of PB, but testing should be done prior to the implementation of these materials to determine proper fertility adjustment needed.

In recent years, substrate stratification, a practice of creating 'layered' substrates inside containers, has been described as a potential solution for improving resource management in container crop production. Fields, Criscione et al. (2022) found that 'Natchez' crapemyrtle had greater root dry weight when grown in stratified substates where finer substate was placed atop of the coarser particles, compared to the unstratified controls. The placement of coarse particles at the bottom half of the container was shown to improve drainage and uniformity of water retention throughout the container profile. Similarly, adding drainage material like gravel or perlite to the bottom of the container promotes proper drainage in the containers.

Maintaining the appropriate pH and electrical conductivity (EC) levels in the substrate is crucial for optimal plant growth in containers. While the natural or properly aged pine bark is generally suitable for crapemyrtle growth (pH range 5.0 - 6.5), testing should be done to determine the pH and EC prior to the mass utilization of the substrate. The reading of pH and EC of the substrate can be obtained by testing 1 cup (236.6 mL) of the substrate mixed with distilled water, using a pH and conductivity testing pen or meter. Ideal pine bark are expected to have a low pH between 3.9 to 6.0 and conductivity range between 0.2 to 0.5 dS/m (mmhos/cm) (Bilderback 2000, Braman, Chappell et al. 2015). The pine bark should not be used if low pH (e.g, pH < 3.8) or high conductivity reading (e.g, 1.5 - 2.5 dS/m) are found as they are potential indicative of unfinished decomposing process and active anaerobic respiration inside the substrate pile. Once plants have established roots in the substrate, monitoring practices such as pour-through technique can be used to maintain optimal plant health and growth. The pour-through technique involves watering the plants sufficiently so that the excess water, or leachate, drains out and can be collected for analysis. By examining the leachate, growers can evaluate the nutrient content and salt accumulation within the container media, and adjust the fertilization as needed to correct any deficiencies or imbalances.

Good sanitation practices in storing and handling substrate are important to eliminate weed seeds, pests, and pathogens that could hinder plant growth. This can be achieved by using commercially available sterilized substrates and proper sterilization of production surface. 10% sodium hypochlorite solution or other commercially available disinfectant can be used to clean recycled containers.

For container nursery production, implementing proper sanitation practices helps minimize the risk of soil-borne diseases, ensuring the health of container-grown crapemyrtle. Bulk substrate inventories should be stored on a concrete slab at the highest elevation in the nursery to avoid contamination from the runoff from the growing areas. The potting bark inventory piles should be kept moisten, under 10 feet, and turned periodically (at least every 3 to 4 weeks), to prevent fire hazards. Frequent turning and mixing of the moisten bark also help prevent fungal colonization of the medium (Braman, Chappell et al. 2015).

Irrigation

Proper irrigation is crucial for the successful container production of crapemyrtle. The frequency and amount of watering depend on various factors such as container size, weather conditions, and plant growth stage. Generally, crapemyrtle planted in containers require more frequent watering than those in the ground. Containers tend to dry out more quickly than the ground, so daily watering may be necessary during hot and dry periods. It is important to monitor the moisture level of the substrate and water the plant when the top inch of substrate feels dry. When growing media containing peat moss or pine bark is used, it is important to avoid the media to dry out. Pine bark-based substrate can tolerate a certain degree of overwatering to suffice the irrigation needs, however, frequent over watering leads to the concern of nutrient leaching from the container (Braman, Chappell et al. 2015).

Irrigation types include overhead irrigation for smaller plants (e.g., in #1, #3, and #5 containers) or liners, while spray stakes or drip irrigation are primarily utilized for larger plants (e.g., in #7, #15, and #25). Best management practices commonly adopted by growers include cyclic irrigation, collection of runoff water, watering in the morning, and implementation of grass strips between production and drainage areas (Garber, Ruter et al. 2002).

Cyclic irrigation or cyclic microirrigation are irrigation practices to apply multiple rounds of subvolume of water instead of applying the total volume at a single time. Cyclic irrigation has several advantages in terms of resource allocation, including reduction of irrigation water input, minimizing water runoff, and reduction of nutrient leaching, compared to continuous irrigation (Fare, Gilliam et al. 1994). For crapemyrtle, research showed that cyclic irrigation using the same volume of water has led to increased plant height, trunk diameter, and shoot dry weight, compared to the controls where irrigation volumes were provided at once (Beeson Jr and Haydu 1995).

Irrigation should aim to provide deep and thorough watering to encourage deep root growth. This helps the plants become more resilient to drought conditions. Water should penetrate the entire root ball and reach the bottom of the container. Avoid shallow and frequent watering, as it can lead to shallow root development and increase the risk of water stress. The leaching fraction from containers (irrigation drainage/total volume applied) and irrigation uniformity should be monitored to evaluate the efficiency of the irrigation system. Ideal leaching fractions for container crapemyrtle production should be between 0.15 and 0.25, but the value might be subjected to large fluctuation due to multiple factors including seasonal changes and pruning practices needed for crapemyrtle (Million and Yeager 2019, Million and Yeager 2021). Automated irrigation systems have been evaluated in recent years and may be implemented by nurseries to effectively lower the water input and maximize plant productivity.

Irrigation regimes may be adjusted according to the specific needs of the crapemyrtle variety and close monitoring. While current research that compares drought resistance levels for other crapemyrtle species and cultivars is limited, crapemyrtles are generally considered to be drought tolerant with little variation in different cultivars. Harp, Chretien et al. (2021) evaluated five 'Ebony' series crapemyrtle and 'Centennial Spirit' for their performance under low input landscape and reported no drought stress among all tested cultivars. On the other hand, (Cabrera 2009) reported the different salinity tolerance levels between 'Pink Lace', 'Natchez', and 'Basham's Party Pink', and 'Basham's Party Pink' was rated as having the most salt tolerance among the three cultivars. Therefore, monitoring the plants' response to irrigation and adjusting watering practices accordingly is crucial to maintain optimal plant health.

Mulching the surface of the container can also help conserve moisture and reduce evaporation. Applying a layer of organic mulch, such as bark chips or straw, around the base of the plant helps to retain soil moisture, regulate soil temperature, and suppress weed growth. There is also an increasing number of growers adopting rice hulls as the mulching material. Studies showed that applying mulch on growing media allows for lowering irrigation volumes and can lead to increased gas exchange and overall plant growth of containerized crapemyrtle (Montague, McKenney et al. 2007).

Fertilization

Fertilization provides the necessary nutrients for healthy growth and abundant flowering of crapemyrtle grown in the container. Under-fertilization results in nutrient deficiencies and stunted growth. On the other hand, over-fertilization can lead to excessive vegetative growth at the expense of flowering and may even cause nutrient imbalances or burn the roots. Here are some key considerations for fertilizing crapemyrtle in container production.

Incorporating controlled-release fertilizers (CRFs) into substrates is a standard practice for fertilizing container plants over an extended period, providing consistent nutrient support to the plants. For general consumers looking to fertilize container-grown crapemyrtle, applying an all-purpose fertilizer with a balanced ratio of nitrogen (N), phosphorus (P), and potassium (K) is a good starting point. Fertilizer formulations such as 10-10-10 NPK with micronutrients (e.g., boron, iron, manganese, zinc, sulfur, magnesium, etc.) provide a well-rounded nutrient supply to support overall plant growth and flower production. For growers producing crapemyrtle at large scale, however, both the substrate and irrigation water should be tested to determine a fertilization regime. Substrates, substrate leachate (~ 50 mL) or plant tissue samples can be submitted to a commercial or university laboratory for a complete analysis of the nutrient levels to obtain specific guidance on fertilization needs (UMass 2023).

For growers, bark substrates in container production must have a complete package of micronutrients, and topdressing new crops of container production with CRFs is common. It is generally recommended to utilize CRFs with a fertilizer nutrient ration of approximately 3:1:2 (N:P:K) for container grown plants (Yeager, Gilliam et al. 1997). Best management practices recommended to supplement substrate with nitrogen at a rate of 3 grams per 1 gallon container (Bilderback 2017). For example, if a fertilizer containing 18(%) N is used, a total of 16.7 g of such fertilizer should be added to a 1-gallon container. Furthermore, studies have shown that fertilizer grades with lower amount of P and K, such as 18-1.7-6.6 and 19-2.6-10.8, are suitable for production of crapemyrtle in container (Shreckhise, Owen et al. 2020, Shreckhise, Owen et al. 2022). However, further lowering the P level in the fertilizer (using a 18.4-1.4-10.2 formulation) was found to negatively affect the shoot dry weight and overall plant quality (Shreckhise, Owen et al. 2022). Pine bark-based substrates were known to be prone to P leaching from containers during irrigation. Therefore, as suggested by Shreckhise, Owen et al. (2020), amending substrate with dolomite and a sulfate-based micronutrient fertilizer is considered a best management practice for crapemyrtle container production.

The placement of CRFs inside the container was found to influence the crapemyrtle growth. (Martin and Ruter 1996) has demonstrated that placing CRF at the north exposure of container has led to the increased plant size of crapemyrtle grown under outdoor nursery conditions. This phenomenon was attributed to the root growth pattern and the root zone temperature inside a sun-exposed container, and thus this practice could be most beneficial for crapemyrtle production in a hot and arid climate area.

When soluble fertilizer is incorporate in the irrigation water, it is important to consider not to utilize high concentration especially when constant feed fertigation is implemented. Cabrera and Devereaux (1999) has reported that 60 ppm N application was optimal in promoting the growth of 'Tonto' crapemyrtle, while higher concentration was shown to cause growth depression. Another study conducted by (Schluckebier and Martin 1997) showed that 'Muskogee' crapemyrtle had the best growth response to the fertigation with 50 microliter/Liter humic acid extract, but the higher concentrations (150 or 300 microliter/Liter) caused growth inhibition. Fertilization at a higher rate was also known to cause reduced flowering in crapemyrtles (Harrison 2006, Buxton 2017).

In addition to regular fertilization, it's beneficial to supplement with micronutrients as needed. Micronutrients, such as iron, manganese, and zinc, are essential for proper plant growth and development. These can be provided through foliar sprays or incorporated into the potting mix, depending on the specific needs of the plants. For example, the foliar application of *Moringa* leaf extract was shown to promote growth and protect crapemyrtle plants against salt stress (Soliman and Shanan 2017).

Timing is important when fertilizing crapemyrtle in containers. Begin fertilization in early spring, once the plants have started to actively grow. Continue fertilizing throughout the growing season, typically until early summer. Avoid fertilizing during winter or periods of dormancy, as excessive vegetative growth prior to dormancy causes winter damage.

Regularly monitor the plants' response to fertilization and adjust the fertilizer application as needed. Assess the overall growth, foliage color, and flower production. If the plants show signs of nutrient deficiencies or excessive growth, consider adjusting the fertilization regimen accordingly.

Pruning

Pruning practice for containerized crapemyrtle promotes plant uniformity, which is beneficial for nursery production (Zajicek, Steinberg et al. 1991).

PRODUCTION COUNTIES

The USDA NASS has documented businesses that grew and sold $10,000 or more of crapemyrtle during each census year since 1997. The number of operations producing crapemyrtle has fluctuated between 800 and 1100 across the United States over the last two decades. As of 2019, there were a total of 823 operations generating crapemyrtle sales in the United States, with 650 involved in wholesale and 269 in retail sales. Crapemyrtle production is conducted in 29 states in 1998 and increased to 33 states in 2019, with most states located in the southeastern part of the continental United States. Florida has the greatest number of operations involved in the production or selling of crapemyrtle, followed by North Carolina, California, Tennessee, Texas, Louisiana, Georgia, and Alabama, which together account for approximately 75% of all producers in the United States (Figure 4).

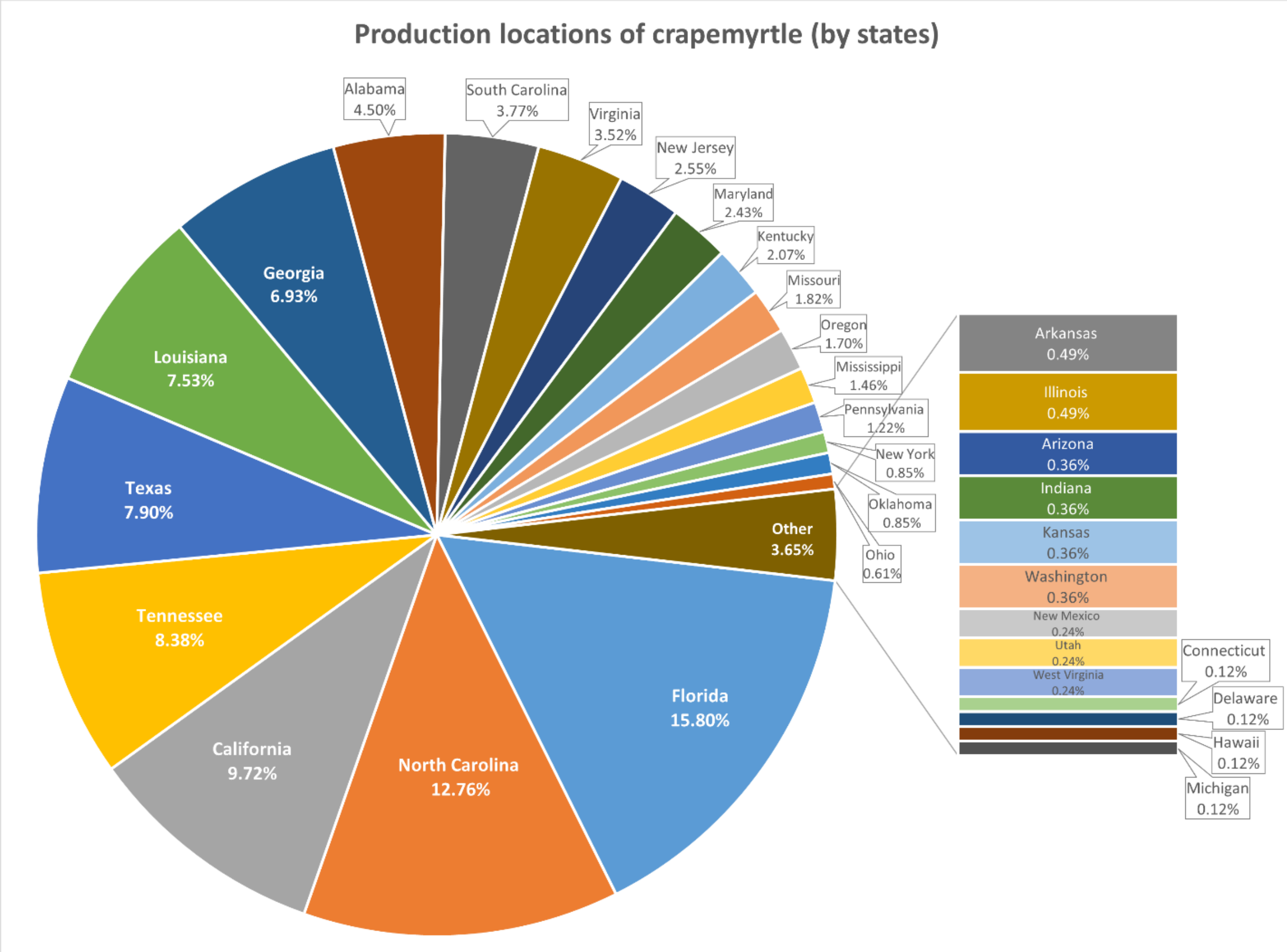
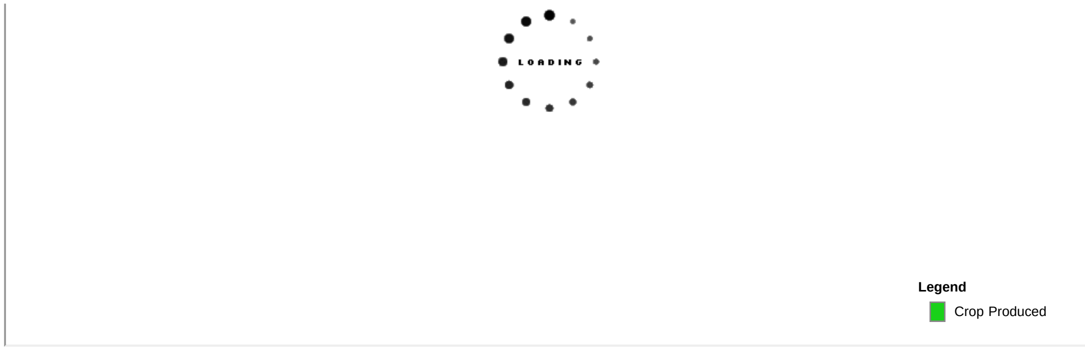


Figure 4: The percentage of crapemyrtle producers in different U.S. states in 2019.



PRODUCTION FACTS

In terms of economic value, crapemyrtle production has an irreplaceable role to play in the green industry. According to the latest USDA report, crapemyrtle generates an increasing market value (annual wholesale values and retail value) of up to $70 million per year, which almost doubled the number since 1988 (USDA, 2001, 2009, 2014, 2019). In 2019, 3.03 million plants with a combined value of $69.57 million were sold (figure 5).

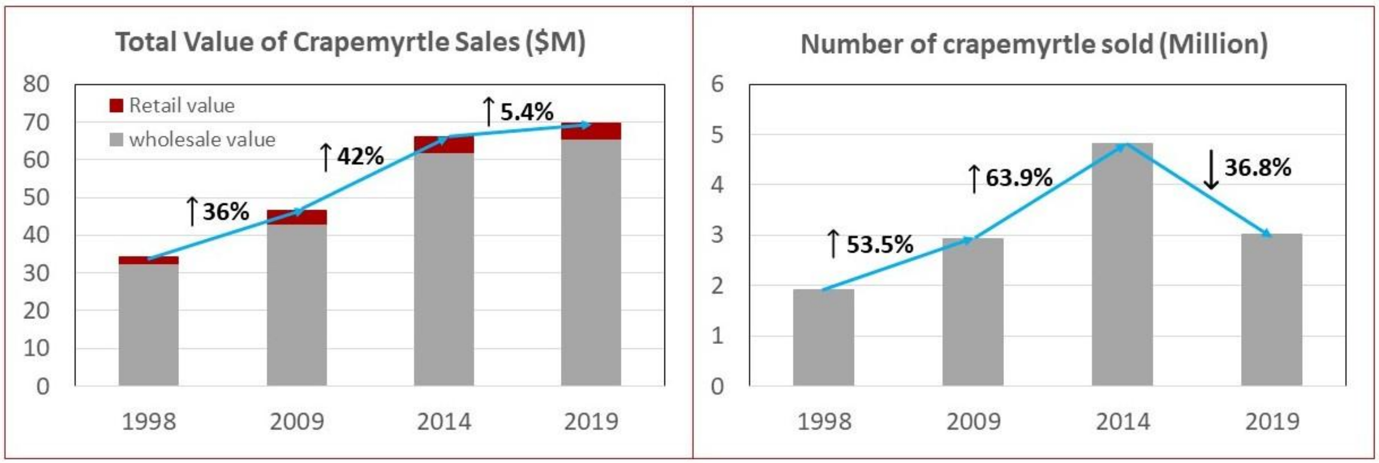


Figure 5: *Total sales of crapemyrtles in 1998, 2009, 2014, and 2019.*

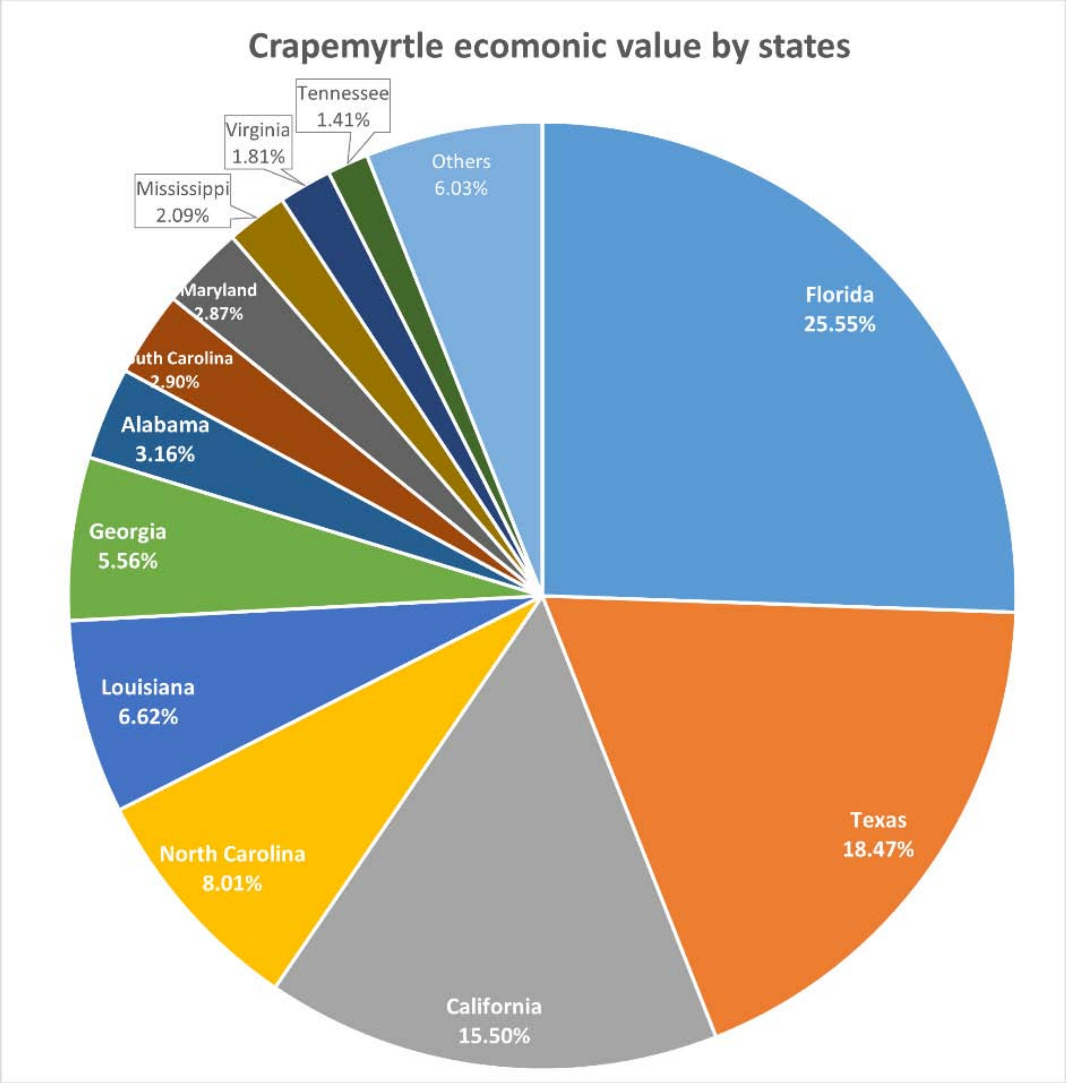


Figure 6: *Crapemyrtle ecomonic values in different U.S. states.*

IPM PRACTICES

Crapemyrtle Bark Scale (*Acanthococcus lagerstroemiae*)

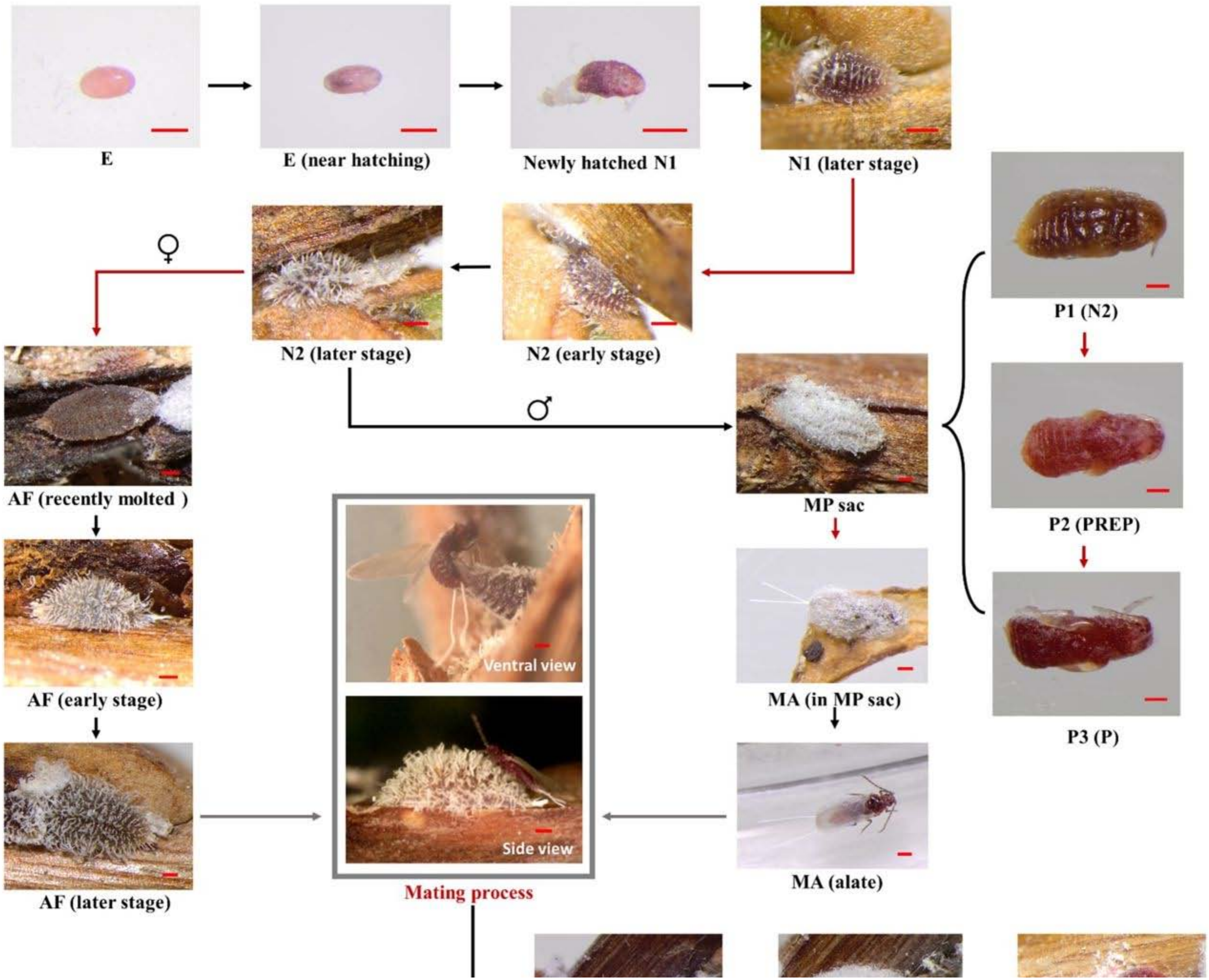
Introduction of crapemyrtle bark scale

Crapemyrtle bark scale (CMBS; *Acanthococcus lagerstroemiae*), an invasive polyphagous sap feeder in the United States, has spread across 17 U.S. states in less than two decades, posing potential risks to the Green Industry.

Crapemyrtle bark scale is a hemipterous insect under the superfamily of Coccoidea (scale insects), which is closely related to other piercing-sucking insects such as mealybugs (Pseudococcidae), aphids (Aphididae), whiteflies (Aleyrodidae), and psyllids (Psyllidae). According to previous studies and observations, the number of CMBS generations within one-year ranges from two to four depending on the climate zones. In the Southeastern United States, CMBS-infested plants can be found in the field year-round, with up to four generations of CMBS being observed in Dallas, TX in 1 year. However, the lack of in-depth characterization of CMBS biological parameters, such as developmental stages, reproductive behavior, and fecundity, limits the research capacity to investigate controlling strategies based on insect biology and physiology.

Life cycle

The life cycle duration of CMBS varies according to different factors, such as temperature and host plant genetics. The average duration of one generation was estimated to be between 79 to 147 days under lab conditions (Xie et al., 2023). Under field and favorable environments, the mean generation time might be shorten, and it was observed that two to four generations of CMBS can occur in one year depending on the geological locations (Gu et al., 2014; Wang et al., 2016). The life cycle of CMBS males started from egg, which takes around 11 days to hatch when incubated under lab conditions at 25 ° C. The developmental stages for individual insects, such as the 1st and 2nd instars, can be determined by monitoring molting events or by keeping track of the insect exuviae. The duration of 1st and 2nd instar stages are about 14 to 17 days and 29 to 68 days, respectively, depending on the different crapemyrtle used as host. The development of the male pupa was characterized as a three-step process (P1, P2, and P3 stages). Firstly, a P1 stage has been identified, as a 2nd instar forms the elongated 'cocoon' structure typically identified as a male sac in the field (Figure 7). Before P1, 2nd instar nymphs typically retract and detach their stylets from the plant and become mobile. Within a short period (24h), the male 2nd instar will relocate until finally settle down at a location, then start excreting wax to form the white male sac. After P1, the 2nd instar will pupate and push out the exuviates through the rear opening of the male sac. The duration of P1, P2, and P3 is around 4-8, 3-5, and 5-7 days, respectively. Hence, a total of three exuviates will be pushed out from the male sac before adult male emergence. After the molting of the pupa, the adult male usually stays in the pupa sac for several days before emergence. Once exiting the pupa sac, the adult male immediately roams the surrounding environment, presumably searching for the adult female's presence. The development of CMBS males is complete metamorphosis, as pupa and adult male stages can be identified (Figure 7).



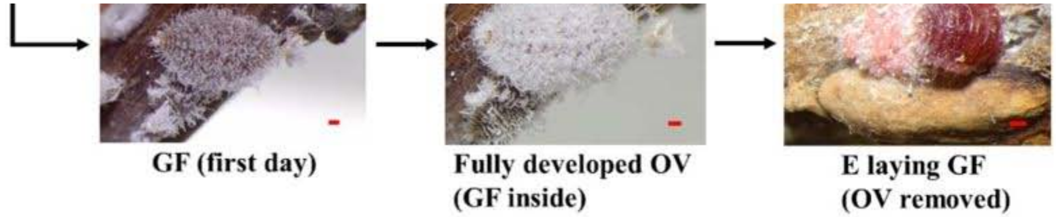


Figure 7 *Detailed life history of crapemyrtle bark scale, Acanthococcus lagerstroemiae. E: Egg, N1: first-instar nymph, N2: second-instar nymph (N1 and N2 are indistinguishable in male and female), AF: adult female (or female third-instar nymph), MP sac: male pupa sac (consist of three stages: P1, P2, and P3), PREP: prepupa, P: pupa, GF: gravid female, OV: ovisac. Scale bars: 200 µm. Arrows represent chronological progression. Red arrows: molting events. Gray arrows and outline: adult males emerge and locate sessile adult females to perform the mating process (Xie et al., 2022).*

Population dynamics

From 2015 to 2017, a monitoring program was implemented across Texas, Louisiana, and Arkansas to track the seasonal population trends of CMBS. This program utilized double-sided tape wrapped around selected branches on a weekly basis. This method proved effective for capturing newly hatched crawlers, thereby revealing patterns of crawler activity throughout the year. The initial surge in crawler activity consistently occurred between March 26th and May 22nd in all studied locations and years, followed by several additional peaks, suggesting the presence of multiple generations of CMBS within a single year. The monitoring program also showed no significant difference in crawler activity levels between the upper and lower branches of crapemyrtle trees throughout the season (Vafaie et al., 2020).

Mating behavior

Mating behavior was observed between adult males and adult females, which is an essential process required for reproduction. Newly emerged adult females typically remain mobile for a short period before settling down at a suitable location to feed on the plants. Thus, most adult females become sessile for the rest of the life cycle, while the alate adult male (once located the female) would initiate the mating process by taping the dorsal side of the female. Upon stimulation, the female reacts by lifting and retracting the rear end of her abdomen to accept copulation. The male then proceeds to curve its abdomen down and direct its genitalia to contact the ventral side of the female abdomen, where sperm transfer could be occurring (Figure7). After the mating process is completed, a reproductive female can be confirmed as the female develops its typical white ovisac structure (Figure 7). As a newly emerged adult female gaining its size, it might be undergoing development for sexual maturity as various adult preproduction periods were recorded. Therefore, depending on the female ages, it would take from 2 to 11 days before the development of ovisac could be observed. Shortly after the ovisac is developed (2-3 days), a female would start laying eggs, and the reproduction period can last up to 10 days.

Feeding behavior

As a sap-sucking insect, the feeding behavior of CMBS involves penetration of the plant epidermis and cortex tissues (using their mouthparts/stylets) to access the nutrient and water content in plant phloem and xylem. The Electrical Penetration Graph (EPG) technique enables the real-time monitoring of the insect's probing activities in plant tissues by analyzing the generated EPG waveforms. Five distinct EPG waveforms—C, potential drop, E1, E2, and G—have been identified for CMBS on the validated host plant, L. limii (Wu et al., 2022). Waveform C indicates the stylet pathway phase, during which the insect begins probing and carrying out extracellular stylet pathway activities. At this stage, sudden changes in voltages (potential drops) were observed, suggesting insects are actively puncturing living plant cells using stylets. Following the stylet pathway phase, the E and G waveforms signify successful access to the phloem and xylem, respectively, indicative of successful feeding activity. Consequently, the insect's difficulty or ease in accessing the phloem and xylem is correlated with the plant's resistance level to CMBS. This resistance level can be effectively assessed using the EPG technique, providing a valuable tool for evaluating a plant's susceptibility to CMBS infestation.

CMBS alternative hosts and feeding preference

Crapemyrtle bark scale has long been reported with a fairly wide host range. Online insect databases such as Scalenet has accumulated a good amount of host information for CMBS. However, recently, as the distribution of CMBS continues to expand beyond its native regions, more specifically in the United States, concerns have been raised regarding the expanded host range for CMBS beyond *Lagerstroemia*, and the potential threats that CMBS poses to the native and economic important plants in the United States.

To address these issues, several studies has been conducted on the feeding preference and host range of CMBS. Greenhouse trials confirmed quite a few species as CMBS hosts, which provided different/additional findings to the previous knowledge regarding CMBS hosts. Here is a summarization of the current knowledge on CMBS hosts.

Greenhouse trials

Multiple greenhouse trials were conducted between 2016 and 2020. All tested plants species were inoculated with CMBS-infested crapemyrtle twigs. CMBS infestation was identified as the presence of both male pupae and gravid female ovisacs during our experimental period, indicating the ability of CMBS to complete life cycle and reproduction on test plants.

For the economic plants in the United States, the infestations of CMBS were confirmed on apple (*Malus domestica*), *Chaenomeles speciosa*, *Disopyros rhombifolia*, *Heimia salicifolia*, *Lagerstroemia* 'Spiced Plum', *M. angustifolia*, and twelve out of thirty-five pomegranate cultivars. However, the levels of CMBS infestation on these test plant hosts in this study are very low compared to *Lagerstroemia* and may not cause significant damage. No sign of CMBS infestation was observed on *Rubus* 'Arapaho', *R.* 'Navaho', *R. idaeus* 'Dorman Red', *R. fruticosus*, *Buxus microphylla* var. *koreana* × *B. sempervirens*, *B. harlandii*, or *D. virginiana* in 2019. Although in a follow-up study with increased CMBS inoculation, one gravid female ovisac was observed on *D. virginiana* in 2020.

In this study, compared to crapemyrtle, all other species had very LOW number of scales, if any. For example, at its peak *L.* 'Spiced Plum' had 600 male pupae, *Heimia* had about 25 and all others had less than 10 (or even 5). Manuscript on this study 'Feeding Preference of Crapemyrtle Bark Scale (*Acanthococcus lagerstroemiae*) on Different Species' was published in June 2020 (https://www.mdpi.com/2075-4450/11/7/399).

Table 1 below summarized all our tested plants in four categories: Severe, Moderate, Minor, and None depending on the level of infestation recorded during our CMBS feeding experiments.

Table 1 Summarization of the crapemyrtle bark scale hosts with different levels of infestation.

Level of infestationX

	Severe	Moderate	Minor	None
Plant species	*Callicarpa americana* 'Bok Tower'	*Callicarpa acuminata*	*Callicarpa bodinieri* 'Profusion'	*Buxus harlandii*
	Callicarpa dichotoma 'Issai'	*Callicarpa japonica* var. *luxurians*	*Chaenomeles speciosa*	*Buxus microphylla* var. *koreana* × *Buxus sempervirens*
	Callicarpa longissima 'Alba'	*Callicarpa pilosissima*	*Disopyros rhombifolia*	*Ficus pumila*
	Lagerstroemia 'Spiced Plum'	*Callicarpa randaiensis*	*Disopyros virginiana*	*Ficus roxburghii*
	Lagerstroemia caudata	*Callicarpa salicifolia*	*Ficus tikoua*	*Rubus* 'Arapaho'
	Lagerstroemia fauriei 'Kiowa'	*Heimia salicifolia*	*Glycine max*	*Rubus* 'Navaho'
	Lagerstroemia limii	*Hypericum kalmianum*	*Malus angustifolia*	*Rubus* fruticosus
	Lagerstroemia subcostata	*Lagerstroemia speciosa*	*Punica granatum*Y	*Rubus idaeus* 'Dorman Red'
		Lythrum californicum		
		Malus domestica		
		*Spiraea japonica*Z		

X Levels of CMBS infestation were defined as: Severe (>100 female ovisacs per plant), Moderate (10-100 female ovisacs per plant), Minor (<10 female ovisacs per plant), and None (no CMBS pupae or ovisacs).

Y twelve out of thirty-five pomegranate cultivars were confirmed with minor CMBS infestation

Z need to be confirmed through DNA identification.

Host suitability among *Lagerstroemia*

The primary hosts of CMBS, as where CMBS got the common name from, are considered to be crapemyrtle or *Lagerstroemia*. However, other than the previously reported *L. indica* and *L. fauriei,* which are the most popular parentage of commercially available *Lagerstroemia* cultivars, the host suitability for CMBS among many other species in this genus remained unknown.

An independent study led by Bin Wu evaluated six *Lagerstroemia* species (*L. caudata*, *L. fauriei* 'Kiowa', *L. indica* 'Dynamite', *L. limii*, *L. speciosa*, and *L. subcostata*) and California loosestrife (*Lythrum californicum*) as CMBS hosts. Greenhouse experiment was conducted over a 25-week period and CMBS infestation were found on all tested plant species, although *L. speciosa* and *Lythrum californicum* had relatively low levels of infestation. For example, among the species with most severe infestations, *L. limii* had around 1000 male pupae and 600 female ovisacs, respectively, per plant at the peak of CMBS population. In contrast, *L. speciosa* had the highest around 45 male pupae and 57 female ovisacs, respectively.

The result suggests that the susceptibility towards CMBS differs among different *Lagerstroemia* species, and the species with low CMBS infestation, such as *L. caudata* and *L. speciose* may be utilized in the future breeding programs to develop CMBS resistant *Lagerstroemia* cultivars.

Host suitability among *Callicarpa* and *Ficus* Species

American Beautyberry*, or Callicarpa americana*, was one of the earlier alternative hosts reported for CMBS in the United States (Wang et al., 2016). The fact that *Callicarpa americana* is a native species in the US was worrisome, therefore, there was a need to evaluate the potential threat of CMBS to the genus of *Callicarpa*.

A greenhouse trials, also led by Bin Wu, confirmed CMBS infestation on nine *Callicarpa* species (*C. acuminata*, *C. americana* 'Bok Tower', *C. bodinieri* 'Profusion', *C. dichotoma* 'Issai', *C. japonica* var. luxurians, *C. longissima* 'Alba', *C. pilosissima*, *C. randaiensis*, and *C. salicifolia*) in 2019. Similar to all other species evaluated, the tested *Callicarpa* species can be categorized into three groups (severe, moderate, and minor) according to the level of CMBS infestation during the experiment. The most severe infestation recorded was on *C. dichotoma* 'Issai' (around 332 male pupae and 246 female ovisacs, respectively), while *C. bodinieri* 'Profusion' suffered the least (around 12 male pupae and 6 female ovisacs, respectively) from CMBS infestation. Unfortunately, none of all the Callicarpa evaluated was completely immune from CMBS attack.

Three *Ficus* species (*F. pumila*, *F. roxburghii*, and *F. tikoua*) were also evaluated in this study. No signs of CMBS infestation found on either *F. pumila* or *F. roxburghii. F. tikoua* had very minor CMBS infestation, which only 3 male pupae and 2 gravid female ovisacs per plant observed during the 25-week period in 2019.

Observation on soybean

Soybean, or *Glycine max*, was documented as one of the alternative hosts of CMBS in Asia. As an economically important agricultural crop in the United States, soybean generates over 40 billion in raw production value annually, and the United States continues to be one of the largest producers and exporters of soybean in the world (Hart, 2017). Therefore, it is reasonable to raise concern for the potential threat of CMBS to damage the soybean production in the United States.

Several greenhouse trials to evaluate the potential threat of CMBS to soybean. Although the presence of CMBS ovisac was observed on soybean plants under controlled environment, the infestation level is very LOW. Figure 8 shows the presence of active nymphs and opened female ovisac with visible pink eggs in it, as well as signs of black sooty mold accumulation, indicating CMBS feeding and reproducing on soybean.

Figure 8: nymphs and gravid females (opened ovisac with visible pink eggs) found on soybean plants (Glycine max) under controlled environment.

Observation in landscape and DNA identification

In 2018, an unknown scale infestation was first observed on *Hypericum kalmianum* (St. Johnswort) in a demonstration garden plot of Virginia Tech and the Virginia Agricultural Experiment Station in Virginia Beach, VA, USA. It was later confirmed by Schultz et al., through both morphological and molecular examinations, that this infestation on *Hypericum* was indeed caused by CMBS (Schultz, Szalanski, & Entomology, 2019). In 2020, a scale infestation observed on *Spiraea japonica* 'Shirobana' at University of Arkansas, has been confirmed as caused by CMBS through morphological and molecular identification (Xie et al., 2021).

Non-suitable hosts of CMBS

Several species or genus were determined as non-suitable hosts for CMBS, despite some of which has previously been documented as CMBS hosts. For example, no CMBS infestation on *Myrtus communis* or *Ligustrum curvifolium* in greenhoust trials. Although *Buxus* and *Rubus* were genus listed as CMBS hosts, no infestation has been observed under greenhouse condtions. It is possible that the previously reported CMBS hosts from these genera were varieties or cultivars naturally found or developed in the native region where CMBS was originally found.

Japanese Beetle (*Popillia japonica*)

The Japanese beetle (*Popillia japonica* Newman) (Scarabaeidae: Coleoptera), native to US, is present in most of states in the eastern US. It is a highly devastating pest, attacking a varieties of crape myrtle. Adults are shiny and attractive, medium sized, ovoid shaped beetles, about 0.5 inches in length, with metallic green colored bodies and iridescent bronze-colored elytra. The elytra do not cover the body completely, thus exposing 6 small tufts of white hair along the sides of the abdomen, under the wing edges. This is an important identifying character that distinguishes these beetles from other similar looking ones. Females are typically slightly larger than males. The adults are weak, clumsy fliers, often falling several times when they hit obstacles in their path. However, they are known to travel long distances.

The beetles are first seen in late spring or early summer, feeding actively on foliage and flowers of various host plants. The mature females lay eggs in clutches of 20-40, buried about 2-3 inches deep in the soil. Eggs are variable in shape, from spheroidal to ellipsoidal or cylindrical, about 1/16 in long, and creamy white in color. They hatch by mid-summer and the grubs feed on plant roots. The grubs are stout and creamy white in color with a brown head and 3 pairs of legs, and are usually found in a curled position. The posterior part of the abdomen has a grayish or black tinge due to accumulation of fecal matter. The full-grown grubs measure about 1 inch in length. By late fall, the grubs dig deeper into the soil for the winter. When the weather gets warmer, the grubs move back towards the surface and resume feeding on plant roots. By late spring, they pupate in the soil. The pupae are pale in color and resemble the adult, but the wings and appendages are folded closely to the body. After 2 weeks, the adults emerge from the ground. The complete life cycle takes about one year, and the beetles usually have one generation per year.

Asian Ambrosia Beetle (*Xylosandrus crassiusculus*)

Granulate ambrosia beetle (*Xylosandrus crassiusculus* (Mot.) is a serious pest of woody trees and shrubs including crape myrtle in the eastern US. This was previously known as the Asian ambrosia beetle. These tiny beetles were first detected in South Carolina in the 1970's and have spread across the eastern US. Woody ornamental nursery plants and fruit trees are commonly affected. In spring or even in late winter (around mid-February), a large number of beetles can emerge and attack tree species, especially when they are young and stressed. The female beetles land on the bark of woody trees. Then, they bore through the inner bark and softwood of the tree, settling in the heartwood where they begin carving galleries.

Females of granulate ambrosia beetle commonly attack trunks of young nursery trees and woody shrubs, although mature trees under stress are also susceptible. They drill a network of tunnels within the heartwood where they lay eggs. Similar to other beetles, granulate ambrosia beetle has egg, larval, pupal and adult stages. Except for adults, all other stages occur only within the tree trunk. In the galleries, eggs, larval stages and pupae can occur together. Adults introduce symbiotic "ambrosia" fungi into the galleries as a food source for the developing larvae. Adults feed on the same fungi and remain along with their young until they mature and become adults. The female granulate ambrosia beetle is about 2.5 mm long. The young females mate with their male siblings within the galleries. Females can readily fly, whereas the males are flightless and do not emerge from the home gallery. Mated females leave the host trees seeking new trees to invade and lay eggs. They attack trees stressed by drought, flooding, mechanical wounding and but also trees that are apparently healthy. Typically, infestations are found below shoulder height on the tree.

PESTS

Insects

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Crapemyrtle aphid (*Sarucallis kahawaluokalani*)	High	A sap-sucking hemipteran (Hemiptera: Aphidoidea) that is host-specific to crapemyrtle compared to the polyphagous insects (such as crapemyrtle bark scale).	Primarily feeds on the underside of the leaves and prefers the more juvenile part of the plant. Heavy infestation caused leaf drop and slowed or stunted plant growth and even plant death. Crapemyrtle aphids produce copious amount of honeydew during feeding, causing black sooty mold on plants further affects plant growth.	abamectin acetamiprid afidopyropen dinotefuran flonicamid imidacloprid pyriproxyfen spirotetramat thiamethoxam	• lady beetles (adult and larvae) • green lacewings (adult and larvae) • hover fly maggots • parasitic wasps • entomophagous fungi	• Insecticidal soap • Horticultural oil • Neem oil • Hard water spray can be used when pest pressure is low	Utilization of resistant Species or cultivars. Crapemyrtle aphid infestation was found to be influenced by different cultivars with different plant features, including sizes (e.g., dwarf, medium, and tall types) and resistance levels to powdery mildew (Mizell Iii and Knox, 1993). Queen's crapemyrle (*Lagerstroemia speciosa*) was reported to be an unsuitable host for crapemyrtle aphids, potentially due to the immature-stage insects' rejection of tested leaves (Herbert et al., 2009).
Crapemyrtle bark scale (*Acanthococcus lagerstroemiae*)	High	An invasive polyphagous sap feeder in the United States, has spread across 16 U.S. states in less than two decades, posing potential risks to the Green Industry. Under the superfamily of Coccoidea (scale insects), which is closely related to other piercing-sucking insects such as mealybugs (Pseudococcidae), aphids (Aphididae), whiteflies (Aleyrodidae), and psyllids (Psyllidae).	Slow and weakened plant growth, leaf abscission, absence of flowering, death of branches, and, in severe cases, the death of the juvenile seedling or young crapemyrtle trees. Another major issue is the accumulation of black sooty mold, caused by the honeydew secretion.	bifenthrin buprofezin cyantraniliprole dinotefuran flupyradifurone imidacloprid pyriproxyfen thiamethoxam Bark spray + Root injection or drench of systemic insecticides with active ingredients including: Dinotefuran, Bifenthrin, Pyriproxyfen, Flupyradifurone, Cyantraniliprole, Imidacloprid, Buprofezin, Thiamethoxam (Vafaie and Knight 2017, Vafaie and Gu 2019, Vafaie 2019, Vafaie 2021, Layton, Pierce et al. 2022).	• Lady beetles (adult and larvae) • Green lacewings (adult and larvae) • Fungal biopesticides: *Beauveria bassiana* showed efficacy in controlling CMBS. Applications in autumn and winter resulted in higher scale mortality (Franco, Chen et al. 2022).	• Horticultural oil use in dormant seasons • Power wash with pressurized water	Planting and breeding of insect-resistant or -tolerant plants have potential to control CMBS. Studies showed different levels of host suitability among crapemyrtle species and cultivars for CMBS. For example, greenhouse trial over a 25-week period showed that *L. limii* had around 1,000 male pupae and 600 female ovisacs, respectively, per plant at the peak of CMBS population. In contrast, *L. speciosa* had the highest around 45 male pupae and 57 female

							ovisacs, respectively.
Granulate ambrosia beetle (*Xylosandrus crassiusculus*)	Low	Granulate ambrosia beetle (Xylosandrus crassiusculus (Mot.) is a serious pest of woody trees and shrubs including crape myrtle in the eastern US. This was previously known as the Asian ambrosia beetle.	Females bore into twigs, branches or trunks and infestations can be identified by toothpick-like boring dust strands protruding up to 1.5 inches from the host plant. Boring leads to fungus diseases such as ambrosia fungus and *Fusarium* spp (Frank, Bambara et al. 2019). Infestations are typically found below shoulder height on the tree.	bifenthrin permethrin Pyrethroid such as permethrin or bifenthrin (Frank, Bambara et al. 2019).			Keep trees healthy and avoid any unnecessary tree stress (drought, injury, nutrition, etc.). Monitoring beetle activity using traps such as ethyl alchohol based traps (Frank, Bambara et al. 2019) and bolt trap (Joseph, Hudson et al. 2019).
Japanese beetle (*Popillia japonica*)	High in Some Locations	The Japanese beetle (*Popillia japonica* Newman) (Scarabaeidae: Coleoptera), native to US, is present in most of states in the eastern US. It is a highly devastating pest, attacking a variety of crapemyrtle.	The beetles are first seen in late spring or early summer, feeding actively on foliage and flowers of various host plants.	acephate bifenthrin carbaryl chlorantraniliprole cyfluthrin deltamethrin halofenozide imidacloprid lambda-cyhalothrin permethrin • Pesticides containing neem oil, acephate, or pyrethroids (bifenthrin, cyfluthrin, lambda cyhalothrin, permethrin) (Blake, Doubrava et al. 2021). • Control for adults: Bifenthrin, Carbaryl, Cyfluthrin, Deltamethrin, Permethrin (USDA 2015). • Control for larvae: Imidacloprid, Halofenzide, Chlorantraniliprole (USDA 2015).	• Nematodes: *Steinernema glaseri* and *Heterorhabditis bacteriophora*. • Microbial insecticide: *Bacillus thuringiensis* (Bt) and *Bacillus papillae* (Milky Spore). • Parasites: *Tiphia vernalis*, *Istocheta aldrichi*, *Tiphia vernalis*, *Istocheta aldrichi* (USDA 2015).	Implement mechanical traps designed to attract and trap the adult beetles.	Planting resistant plant species.
Metallic flea beetles (*Altica spp.*)	Medium	Small, dark metallic, blue-green leaf beetle. *Altica litigata* is also known as crapemyrtle flea beetle.	Adults feed on leaves, leaving irregular chewing holes. Heavy infestation can lead to complete defoliation of the young branches.		• Tachinidae family parasitoids (Diptera). • Braconidae family parasitoids (Hymenoptera). • *Spirotrichum globuliferum* fungus (LeSage 1995).		Removal of potential weed hosts of *Altica litigata* from crapemyrtle' growing areas. Planting of resistant cultivars including 'Acoma', 'Lipan', 'Muskogee', 'Natchez', 'Osage', 'Tonto', and 'Tuscarora' (Chappell, Braman et al. 2012). Scouting for insect activity on crapemyrtle in early spring.
Thrips (*Thysanoptera: Thripidae*)	Medium	Different thrip species, such as the Florida flower thrips (*Frankliniella bispinosa*), are pests known to infest crapemyrtle in the southeastern United States. They undergo partial metamorphosis with five stages: egg, larva (stages I and II), pupa (propupa and pupa stages), and adult.	Thrip feeding leads to deformed growth of leaves, particularly on new growth. Such infestations can stunt the plant's growth, causing new shoots and leaves to appear distorted or curled. Thrips are also found in crapemyrtle flowers (Funderburk, Diffie et al. 2007).				Study showed thrips prefer lighter flower color cultivars such as 'Acoma' (white flower color), compared to lavender 'Apalachee', red 'Carolina Beauty', and pink 'Choctaw' (Funderburk, Funderburk et al. 2015).
Whitefly (*Hemiptera: Aleyrodidae*)	High in Some Locations	Whiteflies, such as *Bemisia tabaci*, are tiny, winged, sap-sucking insects that are found on crapemyrtle.	May become abundant and characterized by their powdery white appearance and their tendency to cluster on the undersides of leaves. Infestation leads to yellowing leaves and stunted growth. Whiteflies also excrete honeydew that support the growth of sooty mold.		Natural enemies, such as lacewings, bigeyed bugs, minute pirate bugs and lady beetles, will provide adequate control of whiteflies.		

Pathogens

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Bacterial spot (*Xanthomonas spp.*)	Low	A leaf spot disease caused by an unidentified *Xanthomonas* bacterium species. The disease begins from the lower leaves and progresses upward. The severity of disease is higher on tightly spaced and nutrient-stressed plants.	Manifests as dark brown, angular to irregular oily-looking spots with a yellow halo on leaves. Leaves infected by this disease typically change color from yellow to red and may fall off prematurely. This condition is commonly observed on the lower leaves of nutrient-stressed and closely planted crapemyrtles.	mancozeb Copper based chemical such as , O-ethyl phosphonate, or Mancozeb) are available for controlling this disease on ornamentals (Chase, 1992; Monteiro et al., 2022), but their effectiveness on crapemyrtle have not been evaluated.			
Botryosphaeria canker (*botryosphaeria spp.*)	Low	Botryosphaeria canker, caused by *Botryosphaeria*, is a fungal pathogen known to infect crapemyrtle (Bush, 2018), potentially causing severe dieback or plant death.	Wilted or dieback branches on an otherwise healthy tree. The wood under the bark turns brown to reddish-brown, not white. Cankers may look sunken, darkened, or be outlined by callused wood. Bark may peel off from affected areas, and black spore-producing structures may be visible on the bark.	No effective fungicide controls.			• Prevent plant stress from drought or poor drainage. • Avoid improper pruning that can injure the plant.
Mushroom root rot (*Armillaria tabescens, Ganoderma lucidum or Armillaria mellea*)	Low	A fungal disease that leads to root decay in various landscape plants, including crapemyrtle. It is common in soils where oaks once grew, as the responsible fungi persist in the environment even after the trees have been removed.	Affected trees may exhibit stunted growth, wilting, and premature leaf drop. The decay of roots can go unnoticed until the tree begins to show signs of stress above ground. mushrooms may appear at the base of the tree, indicating a severe infection.				Keeping the crapemyrtle healthy and minimizing stress.
Phyllosticta leaf spots (*Phyllosticta*)	Low	This is a minor fungal disease and causes insignificant damage to the plant.	The disease starts with small, varying colored spots on leaves that may enlarge and coalesce, leading to ragged holes. Severely infected leaves turn yellow and fall off, often showing black, pinpoint-sized fruiting bodies within the spots.	Chemical application is not recommended. Preventative fungicides can reduce disease occurrence, but they cannot cure already infected plants.			• Practice sanitation by removing leaf litter (do not compost) to prevent spore production. • Fertilize affected trees in early spring. • Prune to thin canopy and enhance air circulation. • Remove dead or weak branches. • Utilize drip irrigation; if using overhead, irrigate early morning to mitigate disease spread.
Phymatotrichum root rot (*Phymatotrichopsis omnivora*)	Low	Also known as Cotton,Texas, or Ozonium root rot, this disease is caused by the destructive fungus *Phymatotrichum omnivorum*, affecting over 2,000 plant species, including ornamentals. Crapemyrtle is moderately susceptible (Taubenhaus and Ezekiel, 1936).					
Powdery mildew (*Erysiphe*)	High	A fungal disease causes significant damage to crape myrtles. The pathogen that produces numerous microscopic spores that are disseminated by wind. Grow favorably under moderate temperature and environment with poor ventilation.	White to grayish powdery growth on the surfaces of leaves, shoots, buds, and flowers. Powdery growth tends to infect, cover, and severely damage younger tissues.	azoxystrobin chlorothalonil mancozeb neem oil, clarified hydrophobic potassium bicarbonate propiconazole tebuconazole trifloxystrobin • Neem oil extract • Potassium bicarbonate • Fungicides with active ingredient (Propicanazole, chlorothalnil, azoxystrobin, trifloxystrobin, tebuconazole, Mancozeb) • Copper-Based Fungicides			• Prevention: use of resistant cultivars: such as Tonto, Muskogee, Acoma, Souix, and Tuskegee. • Improve air circulation. • Proper pruning. • Positioning plants to allow for full sun(Ong, 2004).
Pseudocercospora leaf spot (*Pseudocercospora spp.*)	High	This fungal disease typically develops from mid-summer to fall in wet, humid conditions. Though	Symptoms of Cercospora leaf spot on crapemyrtle are characterized by tan to dark brown spots on	myclobutanil propiconazole tebuconazole			Most sustainable option for control is the use of plant disease

		not a debilitating disease that kills the plant, it impacts the plant's aesthetic appeal by altering leaf coloration.	leaves that turn yellow to red. The infection typically starts on lower leaves and spreads upward. Severely affected plants may experience premature leaf drop, leading to defoliation before frost.	thiophanate-methyl			resistance. The cultivars exhibit good resistance or tolerance include Pink Lace, Pocomoke, Prairie Lace, Red Rocket, Sacramento, Tonto, Tuscarora, Tuskegee, Twilight, Velma's Royal Delight, Wichita, World' Fair, Zuni (Chappell et al., 2012).
Sooty mold (general)	High	Sooty mold, a group of fungal species across various genera, is not directly harmful to plants. However, it can compromise plant health by growing on the sugary secretions left by insects like aphids on leaf surfaces. The sooty mold growth obstructs sunlight, hindering the plant's photosynthesis process.	Black sooty mold on crapemyrtle is caused by saprobic fungi thriving on sugary insect secretions, primarily honeydew from the crapemyrtle aphid. Bark scale also produce sticky exudate.These mold colonies, characterized by darkly pigmented hyphae and spores, vary in shape and size based on the species and infestation level. They can range from thin, black, irregular patches to dense coverings on the plant surfaces.	dinotefuran imidacloprid thiamethoxam Systemic insecticides are effective to control sucking insects (eg: imidacloprid, dinotefuran and thiamethoxam)	Allowing beneficial insects such as lady beetles	Strong spray of water to remove aphids or scale insect	Treating the sooty mold is not necessary; however it can be washed off by spraying with a solution of dish soap, followed by rinsing the foliage with a strong stream of water after a few minutes.

Weeds

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Annual bluegrass (*Poa annua*)	Medium to High	common weedy grass that can be found in residential and commercial turfgrass, ornamental plantings, and gardens.		benefin bensulide clethodim dimethenamid diquat dithiopyr ethofumesate foramsulfuron glufosinate glyphosate nonanoic acid oryzalin oxadiazon pendimethalin prodiamine pronamide sulfosulfuron trifluralin			prevent new infestation by cleaning landscape equipment after use to avoid spread seeds to uninfested areas.
Annual ryegrass (*Lolium multiflorum*)	Low	A populae cover crop choice for growers, can cause issues in field nursery		2,4-d dicamba glyphosate metribuzin paraquat saflufenacil			Often seeded between rows in the fall as living mulch and tilled under in spring.
Bermudagrass (*Cynodon dactylon*)	Medium	Common weed known for its invasive nature, spreading rapidly and overtaking other plants in lawns and gardens. It's tough to control due to its deep roots and resilient growth, making it a nuisance for gardeners and landscapers.		clethodim diquat fluazifop glufosinate glyphosate pelargonic acid sethoxydim triclopyr			Can be controled nonchemically by persistent program of removal; withholding water during summer; ultilize lanscape fabric.
Bittercress (*Cardamine spp.*)	Medium to High	Important broadleaf annual or biennial found in roadside, gardens, lawns, container nuseries, and greenhouse operations.		2,4-d isoxaben napropamide oryzalin oxadiazon triclopyr trifluralin			shalow root systems of this plant allows for hand weeding. Applying mulch is effective for preventing germination.
Broadleaf plantain (*Plantago major*)	Low	perennial, broadleaf weed that can be found in campacted, nutrient-poor soils; thrive in moist, nutrient rich-soils with high calcium.		ferric hedta flumioxazin glufosinate glyphosate indaziflam isoxaben			mulching and removing the weed prior to seed production

				oxyfluorfen trifluralin			
Canadian horseweed (*Erigeron canadensis*)	Medium	Summer annual or biennial broadleaf plant found in cultivated areas and road side.		2,4-d aminopyralid dicamba fluroxypyr 1-methylheptyl ester imazapyr metsulfuron picloram			remove young seedlings as plants are harder to control when taller than 6''. Prevent seed spreading by clean equipment before use or between fields with high pressure water.
Carpetweed (*Mollugo verticillata*)	Low	low-growing, multi-shoot summer annual that grows into a prostrate mat.		dcpa dichlobenil diquat dibromide dithiopyr flumioxazin glyphosate oxyfluorfen			hand pulling, hoeing, and mulching
Common chickweed (*Stellaria media*)	Low	A winter annual broadleaf weed that commonly infests gardens, low-maintenance lawns, and agricultural areas.		benefin dicamba diquat dithiopyr glufosinate glyphosate oryzalin pendimethalin prodiamine triclopyr trifluralin			Hand weeding is practical for small area. Solarization using clear plastic. Using mulch
Common purslane (*Portulaca oleracea*)	Medium	Weedy summer annual invading vegetable gardens, bare areas, low-maintenance lawns, ornamental plantings, and agricultural areas.		2,4-d benefin dicamba dithiopyr mcpp msma oryzalin pendimethalin trifluralin			Hand-pulling of the entire plant without leaving fragments; mulching
Common vetch (*Vicia sativa*)	Low	Common cool season annual weed in the legume family. It has tap root that breaks easily making hand weeding difficult.		2,4-d atrazine dicamba mcpa mecoprop metsulfuron			using digging tool to remove as much of the root system.
Crabgrass (*Digitaria spp.*)	Medium to High	Pervasive annual weed that negatively impacts nurseries, urban, and home landscapes.		fluazifop glufosinate-ammonium glyphosate pelargonic acid quinclorac sethoxydim			prevent re-infestation by seeds
Dandelion (*Taraxacum spp.*)	Low	Perennial broadleaf weed with deep taproot system in gardens and lanscapes		2,4-d acetic acid, (2,4,5-trichlorophenoxy)-, compd. with 1-dodecanamine (1:1) corn gluten meal dicamba fatty acids, c8-12, me esters ferric hedta glyphosate indaziflam isoxaben mcpa mecoprop oxyfluorfen triclopyr			Mulch can be used as a non-chemical management option
Field bindweed (*Convolvulus arvensis*)	Low	One of the most difficult perennial herbaceous weed to control in cultivated field.		2,4-d dicamba glyphosate oryzalin pendimethalin prodiamine trifluralin			Shade from shrubs and trees can reduce the growth of this weed. Sod-forming grasses or dense plantings of bunch grasses and legumes can function as smother crops for cultural control of this

							weed.
Florida betony (*Stachys floridana*)	Low	Can be anggressive broadleaf weed in residential or commercial lanscape such as landscape bed. Usually not an issue for nursery that produce containter-grown plants.		2,4-d atrazine dicamba mcpa mecoprop metsulfuron sulfentrazone triclopyr			frequent mowing of turfgrass at appropriate height can reduce the growth of Florida betony
Giant ragweed (*Ambrosia trifida*)	Low	Summer annial can ermerge from soil depths as deep as 6'', and can reach a height of up to 12 ft tall. Found in landscape, crop field, and disturbed habitats.		2,4-d chlorimuron dicamba glyphosate saflufenacil difficult weed to control with herbicide as resistance to certain classes of herbicide has been reported.			Tillage promotes seedling ermergence of this weed.
Henbit (*Lamium amplexicaule*)	Medium	Weedy annual or biennial in the mint family that is often found in lawns, cultivated fields, along roadsides and other disturbed urban areas.		2,4-d carfentrazone-ethyl dicamba dithiopyr isoxaben mecoprop pendimethalin prodiamine			remove weed before flowering to prevent seed production and further infestation. Small area infestation can be handled by hand weeding or hoe.
Japanese clover (*Kummerowia striata*)	Low	Summer annual that forms 15-18 inch patches or larger, affecting landscape or lawn		2,4-d atrazine clopyralid dicamba dithiopyr isoxaben mcpp metsulfuron quinclorac simazine sulfentrazone triclopyr			hand removing when small infected area is identified; mulching.
Japanese knotweed (*Reynoutria japonica*)	Low	Invasive broadleaf weed that is commonly found along streams and rivers, disturbed areas, landscape, and farmsteads.		aminopyralid glyphosate imazamox imazapyr triclopyr			Single young plants can be pulled by hand but the plant will reprout if root system is not removed entirely.
Johnsongrass (*Sorghum halepense*)	Low	Tough and troublesome warm-season perennial weed that grows well on poor soil and thrive in nutrient-rich soil. Aggressive rhizome growing makes it hard to control.		clethodim dimethenamide-p fenoxaprop p fluazifop-p-butyl glyphosate indaziflam isoxaben napropamide oryzalin oxadiazon oxyfluorfen pendimethalin prodiamine s-metolachlor sethoxydim trifluralin			Hand-weeding might be possible when soil is moist to ensure all vegetative portions are removed.
Nutsedge (*Cyperus spp.*)	High	One of the most important perennial weed problem in cultivated fields in US. Thrive in various habitats, soil types, and moisture conditions.		dichlobenil dimethenamide-p glyphosate metolachlor penoxsulam sulfosulfuron trifloxysulfuron-sodium It is challenging to control mature plant.			A year round program including tillage, soil fumigants, herbicides, and crop rotations are required for effective control of this infestation.
Pigweed (*Amaranthus spp.*)	High	Common broadleaf weed that are major problem for farmers and gardeners. Armed with spines at the base of the leaves at each		dicamba trifluralin			Mulching, mowing before seed production and bagging plants after hand removal to

		node and produces large amount of seeds.					avoid dropping seeds in the field.
Prickly lettuce (*Lactuca serriola*)	Low	Common winter annual or biennial broadleaf weed typically grows 12-40'' from a deep taproot and forms a basal rosette. Milky sap in leaves and stems.		2,4-d atrazine bromoxynil chlorsulfuron dicamba isoxaben mcpa metribuzin metsulfuron oxadiazon oxyfluorfen terbacil thifensulfuron methyl tribenuron			Remove young weeds by pulling or hoeing, and uproot larger weeds before they seed. Apply mulch around vegetables to suppress weed seed germination.
Rooseveltweed (*Baccharis neglecta*)	Low	Weedy, tall shrub that can aggressively inhabit areas with disturbed soil		2,4-d hexazinone			
Shepherd's-purse (*Capsella bursa-pastoris*)	Low	A winter annual broadleaf weed that can be on nurseries, gardens, turf, landscaped areas, roadsides, and other disturbed places.		2,4-d bentazon dicamba diquat dibromide dithiopyr flumioxazin glufosinate-ammonium glyphosate mcpp oryzalin oxadiazon oxyfluorfen pendimethalin prodiamine triclopyr			arly detection and hand pulling; maintain healthy turf that can compete and prevent weed establishment.
Spotted spurge (*Euphorbia maculata*)	High	common warm-season annual weed that can be found in landscape, ornamental bed, and contrainer ornamentals, causing problems on any nursery operation.		2,4-d benefin dicamba dithiopyr glyphosate isoxaben mcpp oryzalin pendimethalin triclopyr trifluralin			Close monitoring of infested area with mechanically removing of plants before seed production, soil solarization, and mulching.
Tall fescue (*Festuca arundinacea*)	Low	cool-season perennial grass that often used as turf grass but can be problematic grassy weed in nursery production and landscape settings.		chlorsulfuron glyphosate			Can be physically removed using shovel or knife when only a few weedy patches exist
Texas blueweed (*Helianthus ciliaris*)	Low	Aggressive weed with a large, stout root system that are resistant to drought.		2,4-d clopyralid dicamba glyphosate mcpa picloram			Mechanically removing and planiting perenneial grasses around infested area to provide competition.
Texas thistle (*Cirsium texanum*)	Low	Common annual to biennial broadleaf weed for landscapers and growers. Prolific seed producer.		2,4-d aminocyclopyrachlor aminopyralid bentazon clopyralid dicamba dichlobenil diflufenzopyr flumioxazin glyphosate imazapic metsulfuron picloram triclopyr			prevent introduction of this weed by early detection and plant removal.

Wildlife

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control

Coyote (*Canis latrans*)	Low						
Deer	Medium						
Foxes ( )	Low						
Rabbits ( )	Low						
Rat, vole, mouse	Low						
Squirrels ( )	Low						

BENEFICIALS

Scientific Name	Common Name	Description	Citation
Adelencyrtus longiclavatus	N/A	Parasitoid of CMBS in India	Hayat M., Alam S.M., Agarwal M.M., Shafee S.A. (1975) Taxonomic survey of encyrtid parasites (Hymenoptera: Encyrtidae) in India Aligarh Muslim University. https://eol.org/pages/849744
Comperiella sp.	N/A	Parasitoid of CMBS in China	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
Clausenia sp.	N/A	Parasitoid of CMBS in China	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
Grandiclavula spatulata	N/A	Parasitoid of CMBS in China	Zhang Y.-Z., Huang D.-W. (2001) Two new Encyrtid parasites (Hymenoptera: Chalcidoidea) from China. Orient Insects 35:311-319.
Marietta picta	N/A	Parasitoid of CMBS in Korea	Suh S.-J. (2019) Notes on some parasitoids (Hymenoptera: Chalcidoidea) associated with Acanthococcus lagerstroemiae (Kuwana)(Hemiptera: Eriococcidae) in the Republic of Korea.
Metaphycus cylindricus	N/A	Parasitoid of CMBS in China	Wang Y., Zhang Y.-Z. (2014) A taxonomic study of Chinese species of the insidiosus group of Metaphycus (Hymenoptera, Encyrtidae). ZooKeys:49.
Metaphycus eriococci	N/A	Parasitoid of CMBS in China and Korea	Wang Y., Zhang Y.-Z. (2014) A taxonomic study of Chinese species of the insidiosus group of Metaphycus (Hymenoptera, Encyrtidae). ZooKeys:49. Suh S.-J. (2019) Notes on some parasitoids (Hymenoptera: Chalcidoidea) associated with Acanthococcus lagerstroemiae (Kuwana)(Hemiptera: Eriococcidae) in the Republic of Korea.
Metaphycus maculatus	N/A	Parasitoid of CMBS in India	Zeya S.B., Hayat M. (1993) A review of the Indian species of Metaphycus (Hymenoptera; Encyrtidae). Orient Insects 27:185-209.
Zaomma eriococci	N/A	Parasitoid of CMBS in Korea	Suh S.-J. (2019) Notes on some parasitoids (Hymenoptera: Chalcidoidea) associated with Acanthococcus lagerstroemiae (Kuwana)(Hemiptera: Eriococcidae) in the Republic of Korea.
Chilocorus cacti	Cactus lady beetle	Predator of CMBS in Louisiana	Wang Z., Chen Y., Diaz R. (2016a) The cactus lady beetle: a voracious predator of scale insects. Bug Biz, Ag Center, LSU 3480:11-15.
Chilocorus kuwanae	Kuwana's lady beetle	Predator of CMBS	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
Chilocorus rubidus	N/A	Predator of CMBS in China	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
Chilocorus stigma	Twice-stabbed lady beetle	Predator of CMBS in Louisiana U.S.	Wang Z., Chen Y., Diaz R. (2016a) The cactus lady beetle: a voracious predator of scale insects. Bug Biz, Ag Center, LSU 3480:11-15.
Cybocephalus nipponicus	Scale picnic beetle or Armoured scale predator		Wang Z., Chen Y., Gu M., Vafaie E., Merchant M., Diaz R. (2016b) Crapemyrtle bark scale: A new threat for crapemyrtles, a popular landscape plant in the U.S. Insects 7:78.
Harmonia axyridis	Asian lady beetle or Halloween beetle	Predator of CMBS in China and the U.S.	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese). Wang Z., Chen Y., Diaz R. (2016a) The cactus lady beetle: a voracious predator of scale insects. Bug Biz, Ag Center, LSU 3480:11-15.
Hyperaspis bigeminata	Bigeminy lady beetle	Predator of CMBS in Louisiana U.S.	Wang Z., Chen Y., Gu M., Vafaie E., Merchant M., Diaz R. (2016b) Crapemyrtle bark scale: A new threat for crapemyrtles, a popular landscape plant in the U.S. Insects 7:78.
Hyperaspis lateralis	Lateral lady beetle	Predator of CMBS in Texas U.S.	Wang Z., Chen Y., Diaz R. (2016a) The cactus lady beetle: a voracious predator of scale insects. Bug Biz, Ag Center, LSU 3480:11-15.
Propylea japonica	Turtle Vein lady beetle	Predator of CMBS in China	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
Rodolia limbata	N/A	Predator of CMBS in China	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
Chrysopa septempunctata or *Chrysopa palens*	Green lacewing	Predator of CMBS in China	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
Chrysopa sinica	Green lacewing	Predator of CMBS in China	Jiang N., Xu H. (1998) Observation on *Eriococcus lagerostroemiae* Kuwana. J Anhui Agric Univ 2:142-144. (in Chinese).
			Wu B., Xie R., Gu M., Qin H. (2022) Green lacewing Chrysoperla

Chrysoperla rufilabris	Red-lipped green lacewing	Predator of CMBS in Texas U.S.	rufilabris (Neuroptera: Chrysopidae) is a potential biological agent for crapemyrtle bark scale (Hemiptera: Eriococcidae) pest management. Technology in Horticulture 2:1-5.

BIOLOGICAL CONTROLS

The biological regulation of crapemyrtle bark scale (CMBS) has been documented in both Asian and American contexts (Wang and Zhang 2014, Wang, Chen et al. 2016, Wang, Chen et al. 2016, Wu, Xie et al. 2022). In Asia, research has identified eight parasitoids from the Encyrtidae family, one parasitoid from the Aphelinidae family, and six predators from the Coccinellidae and Chrysopidae families, all of which have been observed to play a role in mitigating CMBS infestations by significantly diminishing pest populations (Hayat, Alam et al. 1975, Zeya and Hayat 1993, Jiang and Xu 1998, Zhang and Huang 2001, Wang, Chen et al. 2016, Suh 2019). Concurrently, within the United States, a variety of coccinellids—namely *Chilocorus* spp., *Harmonia axyridis, Hyperaspis bigeminata*, and *Hypersapis lateralis*—have been detected actively preying on CMBS (Wang, Chen et al. 2016). Additionally, one green lacewing (*Chrysoperla rufilabris*) was confirmed preying on CMBS in the Texas U.S (Wu, Xie et al. 2022).

Classic biological control focusing on parasitoids;

(see details in Table National Integrated Pest Management (IPM) Database)

Conservative biological control:

To date, there is no documentation indicating the deployment of biological control agents for the conservative biological control of CMBS (Wang, Chen et al. 2016, Franco 2020, Wu, Xie et al. 2022). It is advisable to evaluate specialized parasitoids and predators for CMBS management, given their potential efficacy (Wang, Chen et al. 2016). Parasitoids with a more restricted host range are likely to have a lesser ecological impact compared to more generalist natural enemies. Furthermore, assessing the functional response of these parasitoids or predators to CMBS under quarantine conditions can provide invaluable insights for subsequent releases and large-scale propagation (Wang, Chen et al. 2016). An evaluative approach, employing before-and-after experimental design, can effectively measure the impacts of these parasitoids or predators. In essence, comprehensive assessments are critically needed to inform the development of IPM strategies tailored for the conservative biological control of CMBS.

Augmentation biological control:

In field observations, *Chilocorus cacti*, *Hyperaspis bigeminata*, *Hyperaspis lateralis*, and *Chrysoperla rufilabris* were identified as predators of CMBS. Subsequent laboratory studies confirmed their predatory roles upon CMBS (Wang, Chen et al. 2016, Wu, Xie et al. 2022). However, comprehensive data regarding the life history and voracity of these lady beetles remain to be elucidated to evaluate their potential for augmentative biological control of CMBS (Wang, Chen et al. 2016, Wang, Chen et al. 2016). Additionally, a thorough field investigation into the application of the Red-lipped green lacewing for augmentative biological control of CMBS is an imperative and promising avenue for research, aimed at determining the optimal timing for predator release (Wu, Xie et al. 2022).

CHEMICAL CONTROLS

Disclaimer: The active ingredients and efficacy ratings in this report are not recommendations. The information in this report was provided by the workshop participants as a cross-section of grower practices at that time. Please refer to the pesticide labels for recommendations.

Fungicide

Active Ingredient	Description	Brands	CAS	PC	Pests	REI (hrs)	PHI (days)	FRAC
azoxystrobin			131860-33-	128810	Powdery mildew			
chlorothalonil			1897-45-6	81901	Powdery mildew			
dinotefuran			165252-70-	44312	Sooty mold (general)			
imidacloprid			138261-41-	129099	Sooty mold (general)			
mancozeb			8018-01-7	14504	Powdery mildew, Bacterial spot			
myclobutanil			88671-89-0	128857	Pseudocercospora leaf spot			
neem oil, clarified hydrophobic			947173-77-	25007	Powdery mildew			
potassium bicarbonate			298-14-6	73508	Powdery mildew			
propiconazole			60207-90-1	122101	Powdery mildew, Pseudocercospora leaf spot			
tebuconazole			107534-96-	128997	Powdery mildew, Pseudocercospora leaf spot			
thiamethoxam			153719-23-	60109	Sooty mold (general)			
thiophanate-methyl			23564-05-8	102001	Pseudocercospora leaf spot			
trifloxystrobin			141517-21-	129112	Powdery mildew			

Herbicide

Active Ingredient	Description	Brands	CAS	PC	Pests	REI (hrs)	PHI (days)	HRAC

2,4-d			94-75-7	30001	Giant ragweed, Rooseveltweed, Shepherd's-purse, Bittercress, Texas thistle, Field bindweed, Canadian horseweed, Spotted spurge, Texas blueweed, Japanese clover, Prickly lettuce, Henbit, Annual ryegrass, Common purslane, Florida betony, Dandelion, Common vetch			
acetic acid, (2,4,5-trichlorophenoxy)-, compd. with 1-dodecanamine (1:1)			53404-84-5	82011	Dandelion			
aminocyclopyrachlor			858956-08-	288008	Texas thistle			
aminopyralid			150114-71-	5100	Texas thistle, Canadian horseweed, Japanese knotweed			
atrazine			1912-24-9	80803	Japanese clover, Prickly lettuce, Florida betony, Common vetch			
benefin			1861-40-1	84301	Spotted spurge, Annual bluegrass, Common purslane, Common chickweed			
bensulide			741-58-2	9801	Annual bluegrass			
bentazon			50723-80-3	275200	Shepherd's-purse, Texas thistle			
bromoxynil			1689-84-5	35301	Prickly lettuce			
carfentrazone-ethyl			128639-02-	128712	Henbit			
chlorimuron			90982-32-4	128901	Giant ragweed			
chlorsulfuron			64902-72-3	118601	Tall fescue, Prickly lettuce			
clethodim			99129-21-2	121011	Bermudagrass, Annual bluegrass, Johnsongrass			
clopyralid			1702-17-6	117403	Texas thistle, Texas blueweed, Japanese clover			
corn gluten meal			66071-96-3	100137	Dandelion			
dcpa			1861-32-1	78701	Carpetweed			
dicamba			1918-00-9	29801	Pigweed, Giant ragweed, Shepherd's-purse, Texas thistle, Field bindweed, Canadian horseweed, Spotted spurge, Texas blueweed, Japanese clover, Prickly lettuce, Henbit, Annual ryegrass, Common purslane, Florida betony, Common chickweed, Dandelion, Common vetch			
dichlobenil			1194-65-6	27401	Texas thistle, Nutsedge, Carpetweed			
diflufenzopyr			109293-97-	5108	Texas thistle			
dimethenamid			87674-68-8	129051	Annual bluegrass			
dimethenamide-p			163515-14-	120051	Nutsedge, Johnsongrass			
diquat			2764-72-9	32202	Bermudagrass, Annual bluegrass, Common chickweed			
diquat dibromide			85-00-7	32201	Shepherd's-purse, Carpetweed			
dithiopyr			97886-45-8	128994	Shepherd's-purse, Spotted spurge, Japanese clover, Henbit, Carpetweed, Annual bluegrass, Common purslane, Common chickweed			
ethofumesate			26225-79-6	110601	Annual bluegrass			
fatty acids, c8-12, me esters			67762-39-4	79034	Dandelion			
fenoxaprop p			113158-40-	629093	Johnsongrass			
ferric hedta			17084-02-5	34702	Broadleaf plantain, Dandelion			
fluazifop			69806-50-4	122805	Bermudagrass, Crabgrass			
fluazifop-p-butyl			79241-46-6	122809	Johnsongrass			
flumioxazin			141490-50-	129034	Shepherd's-purse, Texas thistle, Carpetweed, Broadleaf plantain			
fluroxypyr 1-methylheptyl ester			81406-37-3	128968	Canadian horseweed			
foramsulfuron			173159-57-	122020	Annual bluegrass			
glufosinate			77182-82-2	128850	Bermudagrass, Broadleaf plantain, Annual bluegrass, Common chickweed			
glufosinate-ammonium			77182-82-2	128850	Shepherd's-purse, Crabgrass			
glyphosate			1071-83-6	417300	Giant ragweed, Shepherd's-purse, Texas thistle, Field bindweed, Bermudagrass, Nutsedge, Crabgrass, Spotted spurge, Tall fescue, Texas blueweed, Annual ryegrass, Carpetweed, Broadleaf plantain, Annual bluegrass, Japanese knotweed, Johnsongrass, Common chickweed, Dandelion			
hexazinone			51235-04-2	107201	Rooseveltweed			
imazamox			114311-32-	129171	Japanese knotweed			

imazapic			104098-48-	129041	Texas thistle			
imazapyr			81334-34-1	128821	Canadian horseweed, Japanese knotweed			
indaziflam			950782-86-	80818	Broadleaf plantain, Johnsongrass, Dandelion			
isoxaben			82558-50-7	125851	Bittercress, Spotted spurge, Japanese clover, Prickly lettuce, Henbit, Broadleaf plantain, Johnsongrass, Dandelion			
mcpa			94-74-6	30501	Texas blueweed, Prickly lettuce, Florida betony, Dandelion, Common vetch			
mcpp			87394-87-4	600096	Shepherd's-purse, Spotted spurge, Japanese clover, Common purslane			
mecoprop			7085-19-0	31501	Henbit, Florida betony, Dandelion, Common vetch			
metolachlor			51218-45-2	108801	Nutsedge			
metribuzin			21087-64-9	101101	Prickly lettuce, Annual ryegrass			
metsulfuron			74223-64-6	122010	Texas thistle, Canadian horseweed, Japanese clover, Prickly lettuce, Florida betony, Common vetch			
msma			2163-80-6	13803	Common purslane			
napropamide			15299-99-7	103001	Bittercress, Johnsongrass			
nonanoic acid			112-05-0	217500	Annual bluegrass			
oryzalin			19044-88-3	104201	Shepherd's-purse, Bittercress, Field bindweed, Spotted spurge, Annual bluegrass, Common purslane, Johnsongrass, Common chickweed			
oxadiazon			19666-30-9	109001	Shepherd's-purse, Bittercress, Prickly lettuce, Annual bluegrass, Johnsongrass			
oxyfluorfen			42874-03-3	111601	Shepherd's-purse, Prickly lettuce, Carpetweed, Broadleaf plantain, Johnsongrass, Dandelion			
paraquat			4685-14-7	61603	Annual ryegrass			
pelargonic acid			112-05-0	217500	Bermudagrass, Crabgrass			
pendimethalin			40487-42-1	108501	Shepherd's-purse, Field bindweed, Spotted spurge, Henbit, Annual bluegrass, Common purslane, Johnsongrass, Common chickweed			
penoxsulam			219714-96-	119031	Nutsedge			
picloram			1918-02-1	5101	Texas thistle, Canadian horseweed, Texas blueweed			
prodiamine			29091-21-2	110201	Shepherd's-purse, Field bindweed, Henbit, Annual bluegrass, Johnsongrass, Common chickweed			
pronamide			23950-58-5	101701	Annual bluegrass			
quinclorac			84087-01-4	128974	Crabgrass, Japanese clover			
s-metolachlor			87392-12-9	108800	Johnsongrass			
saflufenacil			372137-35-	118203	Giant ragweed, Annual ryegrass			
sethoxydim			74051-80-2	121001	Bermudagrass, Crabgrass, Johnsongrass			
simazine			39312-80-6	80807	Japanese clover			
sulfentrazone			122836-35-	129081	Japanese clover, Florida betony			
sulfosulfuron			141776-32-	85601	Nutsedge, Annual bluegrass			
terbacil			5902-51-2	12701	Prickly lettuce			
thifensulfuron methyl			79277-27-3	128845	Prickly lettuce			
tribenuron			101200-48-	128887	Prickly lettuce			
triclopyr			55335-06-3	116001	Shepherd's-purse, Bittercress, Texas thistle, Bermudagrass, Spotted spurge, Japanese clover, Japanese knotweed, Florida betony, Common chickweed, Dandelion			
trifloxysulfuron-sodium			290332-10-	119009	Nutsedge			
trifluralin			1582-09-8	36101	Pigweed, Bittercress, Field bindweed, Spotted spurge, Broadleaf plantain, Annual bluegrass, Common purslane, Johnsongrass, Common chickweed			

Insecticide

Active Ingredient	Description	Brands	CAS	PC	Pests	REI (hrs)	PHI (days)	IRAC
abamectin			71751-41-2	122804	Crapemyrtle aphid			

acephate			30560-19-1	103301	Japanese beetle			
acetamiprid			135410-20-	99050	Crapemyrtle aphid			
afidopyropen			915972-17-	26200	Crapemyrtle aphid			
bifenthrin			83322-02-5	128825	Crapemyrtle bark scale, Japanese beetle, Granulate ambrosia beetle			
buprofezin			69327-76-0	275100	Crapemyrtle bark scale			
carbaryl			63-25-2	56801	Japanese beetle			
chlorantraniliprole			500008-45-	90100	Japanese beetle			
cyantraniliprole			937279-54-	90098	Crapemyrtle bark scale			
cyfluthrin			68359-37-5	128831	Japanese beetle			
deltamethrin			66841-25-6	97805	Japanese beetle			
dinotefuran			165252-70-	44312	Crapemyrtle bark scale, Crapemyrtle aphid			
flonicamid			158062-67-	128016	Crapemyrtle aphid			
flupyradifurone			951659-40-	122304	Crapemyrtle bark scale			
halofenozide			112226-61-	121026	Japanese beetle			
imidacloprid			138261-41-	129099	Crapemyrtle bark scale, Japanese beetle, Crapemyrtle aphid			
lambda-cyhalothrin			91465-08-6	128897	Japanese beetle			
permethrin			52645-53-1	109701	Japanese beetle, Granulate ambrosia beetle			
pyriproxyfen			95737-68-1	129032	Crapemyrtle bark scale, Crapemyrtle aphid			
spirotetramat				0	Crapemyrtle aphid			
thiamethoxam			153719-23-	60109	Crapemyrtle bark scale, Crapemyrtle aphid			

EFFICACY

Disclaimer: The active ingredients and efficacy ratings in this report are not recommendations. The information in this report was provided by the workshop participants as a cross-section of grower practices at that time. Please refer to the pesticide labels for recommendations.

Insects

Pest	Active Ingredient	PC Code	CAS	Rating	Description/Comments/Resistance Issues
Crapemyrtle aphid	Abamectin	122804	71751-41-2		
Crapemyrtle aphid	Acetamiprid	99050	135410-20-7		
Crapemyrtle aphid	Afidopyropen	26200	915972-17-7		
Crapemyrtle aphid	Dinotefuran	44312	165252-70-0		
Crapemyrtle aphid	Flonicamid	128016	158062-67-0		
Crapemyrtle aphid	Imidacloprid	129099	138261-41-3		
Crapemyrtle aphid	Pyriproxyfen	129032	95737-68-1		
Crapemyrtle aphid	Spirotetramat	0			
Crapemyrtle aphid	Thiamethoxam	60109	153719-23-4		
Crapemyrtle bark scale	Bifenthrin	128825	83322-02-5		
Crapemyrtle bark scale	Buprofezin	275100	69327-76-0		
Crapemyrtle bark scale	Cyantraniliprole	90098	937279-54-4		
Crapemyrtle bark scale	Dinotefuran	44312	165252-70-0		
Crapemyrtle bark scale	Flupyradifurone	122304	951659-40-8		
Crapemyrtle bark scale	Imidacloprid	129099	138261-41-3		
Crapemyrtle bark scale	Pyriproxyfen	129032	95737-68-1		
Crapemyrtle bark scale	Thiamethoxam	60109	153719-23-4		
Granulate ambrosia beetle	Bifenthrin	128825	83322-02-5		
Granulate ambrosia beetle	Permethrin	109701	52645-53-1		
Japanese beetle	Acephate	103301	30560-19-1		
Japanese beetle	Bifenthrin	128825	83322-02-5		
Japanese beetle	Carbaryl	56801	63-25-2		
Japanese beetle	Chlorantraniliprole	90100	500008-45-7		
Japanese beetle	Cyfluthrin	128831	68359-37-5		
Japanese beetle	Deltamethrin	97805	66841-25-6		
Japanese beetle	Halofenozide	121026	112226-61-6		
Japanese beetle	Imidacloprid	129099	138261-41-3		
Japanese beetle	lambda-Cyhalothrin	128897	91465-08-6		

Japanese beetle	Permethrin	109701	52645-53-1		

Pathogens

Pest	Active Ingredient	PC Code	CAS	Rating	Description/Comments/Resistance Issues
Bacterial spot	Mancozeb	14504	8018-01-7		
Powdery mildew	Azoxystrobin	128810	131860-33-8		
Powdery mildew	Chlorothalonil	81901	1897-45-6		
Powdery mildew	Mancozeb	14504	8018-01-7		
Powdery mildew	Neem oil, clarified hydrophobic	25007	947173-77-5		
Powdery mildew	Potassium bicarbonate	73508	298-14-6		
Powdery mildew	Propiconazole	122101	60207-90-1		
Powdery mildew	Tebuconazole	128997	107534-96-3		
Powdery mildew	Trifloxystrobin	129112	141517-21-7		
Pseudocercospora leaf spot	Myclobutanil	128857	88671-89-0		
Pseudocercospora leaf spot	Propiconazole	122101	60207-90-1		
Pseudocercospora leaf spot	Tebuconazole	128997	107534-96-3		
Pseudocercospora leaf spot	Thiophanate-methyl	102001	23564-05-8		
Sooty mold	Dinotefuran	44312	165252-70-0		
Sooty mold	Imidacloprid	129099	138261-41-3		
Sooty mold	Thiamethoxam	60109	153719-23-4		

Weeds

Pest	Active Ingredient	PC Code	CAS	Rating	Description/Comments/Resistance Issues
Annual bluegrass	Benefin	84301	1861-40-1		
Annual bluegrass	Bensulide	9801	741-58-2		
Annual bluegrass	Clethodim	121011	99129-21-2		
Annual bluegrass	Dimethenamid	129051	87674-68-8		
Annual bluegrass	Diquat	32202	2764-72-9		
Annual bluegrass	Dithiopyr	128994	97886-45-8		
Annual bluegrass	Ethofumesate	110601	26225-79-6		
Annual bluegrass	Foramsulfuron	122020	173159-57-4		
Annual bluegrass	Glufosinate	128850	77182-82-2		
Annual bluegrass	Glyphosate	417300	1071-83-6		
Annual bluegrass	Nonanoic acid	217500	112-05-0		
Annual bluegrass	Oryzalin	104201	19044-88-3		
Annual bluegrass	Oxadiazon	109001	19666-30-9		
Annual bluegrass	Pendimethalin	108501	40487-42-1		
Annual bluegrass	Prodiamine	110201	29091-21-2		
Annual bluegrass	Pronamide	101701	23950-58-5		
Annual bluegrass	Sulfosulfuron	85601	141776-32-1		
Annual bluegrass	Trifluralin	36101	1582-09-8		
Annual ryegrass	2,4-D	30001	94-75-7		
Annual ryegrass	Dicamba	29801	1918-00-9		
Annual ryegrass	Glyphosate	417300	1071-83-6		
Annual ryegrass	Metribuzin	101101	21087-64-9		
Annual ryegrass	Paraquat	61603	4685-14-7		
Annual ryegrass	Saflufenacil	118203	372137-35-4		
Bermudagrass	Clethodim	121011	99129-21-2		
Bermudagrass	Diquat	32202	2764-72-9		
Bermudagrass	Fluazifop	122805	69806-50-4		
Bermudagrass	Glufosinate	128850	77182-82-2		
Bermudagrass	Glyphosate	417300	1071-83-6		
Bermudagrass	Pelargonic acid	217500	112-05-0		
Bermudagrass	Sethoxydim	121001	74051-80-2		
Bermudagrass	Triclopyr	116001	55335-06-3		
Bittercress	2,4-D	30001	94-75-7		

Bittercress	Isoxaben	125851	82558-50-7		
Bittercress	Napropamide	103001	15299-99-7		
Bittercress	Oryzalin	104201	19044-88-3		
Bittercress	Oxadiazon	109001	19666-30-9		
Bittercress	Triclopyr	116001	55335-06-3		
Bittercress	Trifluralin	36101	1582-09-8		
Broadleaf plantain	Ferric HEDTA	34702	17084-02-5		
Broadleaf plantain	Flumioxazin	129034	141490-50-8		
Broadleaf plantain	Glufosinate	128850	77182-82-2		
Broadleaf plantain	Glyphosate	417300	1071-83-6		
Broadleaf plantain	Indaziflam	80818	950782-86-2		
Broadleaf plantain	Isoxaben	125851	82558-50-7		
Broadleaf plantain	Oxyfluorfen	111601	42874-03-3		
Broadleaf plantain	Trifluralin	36101	1582-09-8		
Marestail/horseweed	2,4-D	30001	94-75-7		
Marestail/horseweed	Aminopyralid	5100	150114-71-9		
Marestail/horseweed	Dicamba	29801	1918-00-9		
Marestail/horseweed	Fluroxypyr 1-methylheptyl ester	128968	81406-37-3		
Marestail/horseweed	Imazapyr	128821	81334-34-1		
Marestail/horseweed	Metsulfuron	122010	74223-64-6		
Marestail/horseweed	Picloram	5101	1918-02-1		
Carpetweed	DCPA	78701	1861-32-1		
Carpetweed	Dichlobenil	27401	1194-65-6		
Carpetweed	Diquat dibromide	32201	85-00-7		
Carpetweed	Dithiopyr	128994	97886-45-8		
Carpetweed	Flumioxazin	129034	141490-50-8		
Carpetweed	Glyphosate	417300	1071-83-6		
Carpetweed	Oxyfluorfen	111601	42874-03-3		
Chickweed	Benefin	84301	1861-40-1		
Chickweed	Dicamba	29801	1918-00-9		
Chickweed	Diquat	32202	2764-72-9		
Chickweed	Dithiopyr	128994	97886-45-8		
Chickweed	Glufosinate	128850	77182-82-2		
Chickweed	Glyphosate	417300	1071-83-6		
Chickweed	Oryzalin	104201	19044-88-3		
Chickweed	Pendimethalin	108501	40487-42-1		
Chickweed	Prodiamine	110201	29091-21-2		
Chickweed	Triclopyr	116001	55335-06-3		
Chickweed	Trifluralin	36101	1582-09-8		
Common purslane	2,4-D	30001	94-75-7		
Common purslane	Benefin	84301	1861-40-1		
Common purslane	Dicamba	29801	1918-00-9		
Common purslane	Dithiopyr	128994	97886-45-8		
Common purslane	mCPP	600096	87394-87-4		
Common purslane	MSMA	13803	2163-80-6		
Common purslane	Oryzalin	104201	19044-88-3		
Common purslane	Pendimethalin	108501	40487-42-1		
Common purslane	Trifluralin	36101	1582-09-8		
Common vetch	2,4-D	30001	94-75-7		
Common vetch	Atrazine	80803	1912-24-9		
Common vetch	Dicamba	29801	1918-00-9		
Common vetch	MCPA	30501	94-74-6		
Common vetch	Mecoprop	31501	7085-19-0		
Common vetch	Metsulfuron	122010	74223-64-6		
Crabgrass	Fluazifop	122805	69806-50-4		
Crabgrass	Glufosinate-ammonium	128850	77182-82-2		
Crabgrass	Glyphosate	417300	1071-83-6		
Crabgrass	Pelargonic acid	217500	112-05-0		

Crabgrass	Quinclorac	128974	84087-01-4		
Crabgrass	Sethoxydim	121001	74051-80-2		
Dandelion	2,4-D	30001	94-75-7		
Dandelion	Acetic acid, (2,4,5-trichlorophenoxy)-, compd. with 1-dodecanamine (1:1)	82011	53404-84-5		
Dandelion	Corn gluten meal	100137	66071-96-3		
Dandelion	Dicamba	29801	1918-00-9		
Dandelion	Fatty acids, C8-12, Me esters	79034	67762-39-4		
Dandelion	Ferric HEDTA	34702	17084-02-5		
Dandelion	Glyphosate	417300	1071-83-6		
Dandelion	Indaziflam	80818	950782-86-2		
Dandelion	Isoxaben	125851	82558-50-7		
Dandelion	MCPA	30501	94-74-6		
Dandelion	Mecoprop	31501	7085-19-0		
Dandelion	Oxyfluorfen	111601	42874-03-3		
Dandelion	Triclopyr	116001	55335-06-3		
Field bindweed	2,4-D	30001	94-75-7		
Field bindweed	Dicamba	29801	1918-00-9		
Field bindweed	Glyphosate	417300	1071-83-6		
Field bindweed	Oryzalin	104201	19044-88-3		
Field bindweed	Pendimethalin	108501	40487-42-1		
Field bindweed	Prodiamine	110201	29091-21-2		
Field bindweed	Trifluralin	36101	1582-09-8		
Florida betony	2,4-D	30001	94-75-7		
Florida betony	Atrazine	80803	1912-24-9		
Florida betony	Dicamba	29801	1918-00-9		
Florida betony	MCPA	30501	94-74-6		
Florida betony	Mecoprop	31501	7085-19-0		
Florida betony	Metsulfuron	122010	74223-64-6		
Florida betony	Sulfentrazone	129081	122836-35-5		
Florida betony	Triclopyr	116001	55335-06-3		
Henbit	2,4-D	30001	94-75-7		
Henbit	Carfentrazone-ethyl	128712	128639-02-1		
Henbit	Dicamba	29801	1918-00-9		
Henbit	Dithiopyr	128994	97886-45-8		
Henbit	Isoxaben	125851	82558-50-7		
Henbit	Mecoprop	31501	7085-19-0		
Henbit	Pendimethalin	108501	40487-42-1		
Henbit	Prodiamine	110201	29091-21-2		
Japanese clover	2,4-D	30001	94-75-7		
Japanese clover	Atrazine	80803	1912-24-9		
Japanese clover	Clopyralid	117403	1702-17-6		
Japanese clover	Dicamba	29801	1918-00-9		
Japanese clover	Dithiopyr	128994	97886-45-8		
Japanese clover	Isoxaben	125851	82558-50-7		
Japanese clover	mCPP	600096	87394-87-4		
Japanese clover	Metsulfuron	122010	74223-64-6		
Japanese clover	Quinclorac	128974	84087-01-4		
Japanese clover	Simazine	80807	39312-80-6		
Japanese clover	Sulfentrazone	129081	122836-35-5		
Japanese clover	Triclopyr	116001	55335-06-3		
Japanese knotweed	Aminopyralid	5100	150114-71-9		
Japanese knotweed	Glyphosate	417300	1071-83-6		
Japanese knotweed	Imazamox	129171	114311-32-9		
Japanese knotweed	Imazapyr	128821	81334-34-1		
Japanese knotweed	Triclopyr	116001	55335-06-3		
Johnsongrass	Clethodim	121011	99129-21-2		
Johnsongrass	dimethenamide-P	120051	163515-14-8		
Johnsongrass	Fenoxaprop P	629093	113158-40-0		

Johnsongrass	Fluazifop-P-butyl	122809	79241-46-6		
Johnsongrass	Glyphosate	417300	1071-83-6		
Johnsongrass	Indaziflam	80818	950782-86-2		
Johnsongrass	Isoxaben	125851	82558-50-7		
Johnsongrass	Napropamide	103001	15299-99-7		
Johnsongrass	Oryzalin	104201	19044-88-3		
Johnsongrass	Oxadiazon	109001	19666-30-9		
Johnsongrass	Oxyfluorfen	111601	42874-03-3		
Johnsongrass	Pendimethalin	108501	40487-42-1		
Johnsongrass	Prodiamine	110201	29091-21-2		
Johnsongrass	S-Metolachlor	108800	87392-12-9		
Johnsongrass	Sethoxydim	121001	74051-80-2		
Johnsongrass	Trifluralin	36101	1582-09-8		
Nutsedge	Dichlobenil	27401	1194-65-6		
Nutsedge	dimethenamide-P	120051	163515-14-8		
Nutsedge	Glyphosate	417300	1071-83-6		
Nutsedge	Metolachlor	108801	51218-45-2		
Nutsedge	Penoxsulam	119031	219714-96-2		
Nutsedge	Sulfosulfuron	85601	141776-32-1		
Nutsedge	Trifloxysulfuron-sodium	119009	290332-10-4		
Pigweed	Dicamba	29801	1918-00-9		
Pigweed	Trifluralin	36101	1582-09-8		
Prickly lettuce	2,4-D	30001	94-75-7		
Prickly lettuce	Atrazine	80803	1912-24-9		
Prickly lettuce	Bromoxynil	35301	1689-84-5		
Prickly lettuce	Chlorsulfuron	118601	64902-72-3		
Prickly lettuce	Dicamba	29801	1918-00-9		
Prickly lettuce	Isoxaben	125851	82558-50-7		
Prickly lettuce	MCPA	30501	94-74-6		
Prickly lettuce	Metribuzin	101101	21087-64-9		
Prickly lettuce	Metsulfuron	122010	74223-64-6		
Prickly lettuce	Oxadiazon	109001	19666-30-9		
Prickly lettuce	Oxyfluorfen	111601	42874-03-3		
Prickly lettuce	Terbacil	12701	5902-51-2		
Prickly lettuce	Thifensulfuron methyl	128845	79277-27-3		
Prickly lettuce	Tribenuron	128887	101200-48-0		
Ragweed � giant	2,4-D	30001	94-75-7		
Ragweed � giant	Chlorimuron	128901	90982-32-4		
Ragweed � giant	Dicamba	29801	1918-00-9		
Ragweed � giant	Glyphosate	417300	1071-83-6		
Ragweed � giant	Saflufenacil	118203	372137-35-4		
Rooseveltweed	2,4-D	30001	94-75-7		
Rooseveltweed	Hexazinone	107201	51235-04-2		
Shepherdspurse	2,4-D	30001	94-75-7		
Shepherdspurse	Bentazon	275200	50723-80-3		
Shepherdspurse	Dicamba	29801	1918-00-9		
Shepherdspurse	Diquat dibromide	32201	85-00-7		
Shepherdspurse	Dithiopyr	128994	97886-45-8		
Shepherdspurse	Flumioxazin	129034	141490-50-8		
Shepherdspurse	Glufosinate-ammonium	128850	77182-82-2		
Shepherdspurse	Glyphosate	417300	1071-83-6		
Shepherdspurse	mCPP	600096	87394-87-4		
Shepherdspurse	Oryzalin	104201	19044-88-3		
Shepherdspurse	Oxadiazon	109001	19666-30-9		
Shepherdspurse	Oxyfluorfen	111601	42874-03-3		
Shepherdspurse	Pendimethalin	108501	40487-42-1		
Shepherdspurse	Prodiamine	110201	29091-21-2		
Shepherdspurse	Triclopyr	116001	55335-06-3		

Spotted spurge	2,4-D	30001	94-75-7		
Spotted spurge	Benefin	84301	1861-40-1		
Spotted spurge	Dicamba	29801	1918-00-9		
Spotted spurge	Dithiopyr	128994	97886-45-8		
Spotted spurge	Glyphosate	417300	1071-83-6		
Spotted spurge	Isoxaben	125851	82558-50-7		
Spotted spurge	mCPP	600096	87394-87-4		
Spotted spurge	Oryzalin	104201	19044-88-3		
Spotted spurge	Pendimethalin	108501	40487-42-1		
Spotted spurge	Triclopyr	116001	55335-06-3		
Spotted spurge	Trifluralin	36101	1582-09-8		
Tall fescue	Chlorsulfuron	118601	64902-72-3		
Tall fescue	Glyphosate	417300	1071-83-6		
Texas blueweed	2,4-D	30001	94-75-7		
Texas blueweed	Clopyralid	117403	1702-17-6		
Texas blueweed	Dicamba	29801	1918-00-9		
Texas blueweed	Glyphosate	417300	1071-83-6		
Texas blueweed	MCPA	30501	94-74-6		
Texas blueweed	Picloram	5101	1918-02-1		
Texas thistle	2,4-D	30001	94-75-7		
Texas thistle	Aminocyclopyrachlor	288008	858956-08-8		
Texas thistle	Aminopyralid	5100	150114-71-9		
Texas thistle	Bentazon	275200	50723-80-3		
Texas thistle	Clopyralid	117403	1702-17-6		
Texas thistle	Dicamba	29801	1918-00-9		
Texas thistle	Dichlobenil	27401	1194-65-6		
Texas thistle	Diflufenzopyr	5108	109293-97-2		
Texas thistle	Flumioxazin	129034	141490-50-8		
Texas thistle	Glyphosate	417300	1071-83-6		
Texas thistle	Imazapic	129041	104098-48-8		
Texas thistle	Metsulfuron	122010	74223-64-6		
Texas thistle	Picloram	5101	1918-02-1		
Texas thistle	Triclopyr	116001	55335-06-3		

TIMELINES

Production Practices	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Container Production													
Field Production													

Pests	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
crapemyrtle aphid (Insects)													
crapemyrtle bark scale (Insects)													
granulate ambrosia beetle (Insects)													
Japanese beetle (Insects)													
bacterial spot (Pathogens)													
Phyllosticta leaf spots (Pathogens)													
Phymatotrichum root rot (Pathogens)													
powdery mildew (Pathogens)													
Pseudocercospora leaf spot (Pathogens)													
sooty mold (general) (Pathogens)													
annual bluegrass (Weeds)													
annual ryegrass (Weeds)													
bermudagrass (Weeds)													
bittercress (Weeds)													
broadleaf plantain (Weeds)													
Canadian horseweed (Weeds)													
carpetweed (Weeds)													

common chickweed (Weeds)													
common purslane (Weeds)													
common vetch (Weeds)													
crabgrass (Weeds)													
dandelion (Weeds)													
Field Bindweed (Weeds)													
Florida betony (Weeds)													
henbit (Weeds)													
Japanese clover (Weeds)													
Japanese knotweed (Weeds)													
johnsongrass (Weeds)													
pigweed (Weeds)													
prickly lettuce (Weeds)													
giant ragweed (Weeds)													
Rooseveltweed (Weeds)													
shepherd's-purse (Weeds)													
spotted spurge (Weeds)													
tall fescue (Weeds)													
Texas blueweed (Weeds)													
Texas thistle (Weeds)													
Coyote (Wildlife)													
Deer (Wildlife)													
Foxes (Wildlife)													
Rabbits (Wildlife)													
rat, vole, mouse (Wildlife)													
Squirrels (Wildlife)													

Stages	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Dormant													
Dormant													
Delayed Dormant (Bud Breaking)													
6- to 12-Inch Shoot													
Bloom													

Chemicals	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Azoxystrobin (Fungicide)													
Chlorothalonil (Fungicide)													
Dinotefuran (Fungicide)													
Imidacloprid (Fungicide)													
Mancozeb (Fungicide)													
Myclobutanil (Fungicide)													
Neem oil, clarified hydrophobic (Fungicide)													
Potassium bicarbonate (Fungicide)													
Propiconazole (Fungicide)													
Tebuconazole (Fungicide)													
Thiamethoxam (Fungicide)													
Thiophanate-methyl (Fungicide)													
Trifloxystrobin (Fungicide)													
2,4-D (Herbicide)													
Acetic acid, (2,4,5-trichlorophenoxy)-, compd. with 1-dodecanamine (1:1) (Herbicide)													
Aminocyclopyrachlor (Herbicide)													
Aminopyralid (Herbicide)													
Atrazine (Herbicide)													
Benefin (Herbicide)													
Bensulide (Herbicide)													
Bentazon (Herbicide)													
Bromoxynil (Herbicide)													
Carfentrazone-ethyl (Herbicide)													
Chlorimuron (Herbicide)													

Chlorsulfuron (Herbicide)													
Clethodim (Herbicide)													
Clopyralid (Herbicide)													
Corn gluten meal (Herbicide)													
DCPA (Herbicide)													
Dicamba (Herbicide)													
Dichlobenil (Herbicide)													
Diflufenzopyr (Herbicide)													
Dimethenamid (Herbicide)													
dimethenamide-P (Herbicide)													
Diquat (Herbicide)													
Diquat dibromide (Herbicide)													
Dithiopyr (Herbicide)													
Ethofumesate (Herbicide)													
Fatty acids, C8-12, Me esters (Herbicide)													
Fenoxaprop P (Herbicide)													
Ferric HEDTA (Herbicide)													
Fluazifop (Herbicide)													
Fluazifop-P-butyl (Herbicide)													
Flumioxazin (Herbicide)													
Fluroxypyr 1-methylheptyl ester (Herbicide)													
Foramsulfuron (Herbicide)													
Glufosinate (Herbicide)													
Glufosinate-ammonium (Herbicide)													
Glyphosate (Herbicide)													
Hexazinone (Herbicide)													
Imazamox (Herbicide)													
Imazapic (Herbicide)													
Imazapyr (Herbicide)													
Indaziflam (Herbicide)													
Isoxaben (Herbicide)													
MCPA (Herbicide)													
mCPP (Herbicide)													
Mecoprop (Herbicide)													
Metolachlor (Herbicide)													
Metribuzin (Herbicide)													
Metsulfuron (Herbicide)													
MSMA (Herbicide)													
Napropamide (Herbicide)													
Nonanoic acid (Herbicide)													
Oryzalin (Herbicide)													
Oxadiazon (Herbicide)													
Oxyfluorfen (Herbicide)													
Paraquat (Herbicide)													
Pelargonic acid (Herbicide)													
Pendimethalin (Herbicide)													
Penoxsulam (Herbicide)													
Picloram (Herbicide)													
Prodiamine (Herbicide)													
Pronamide (Herbicide)													
Quinclorac (Herbicide)													
S-Metolachlor (Herbicide)													
Saflufenacil (Herbicide)													
Sethoxydim (Herbicide)													
Simazine (Herbicide)													
Sulfentrazone (Herbicide)													
Sulfosulfuron (Herbicide)													
Terbacil (Herbicide)													

Thifensulfuron methyl (Herbicide)													
Tribenuron (Herbicide)													
Triclopyr (Herbicide)													
Trifloxysulfuron-sodium (Herbicide)													
Trifluralin (Herbicide)													
Abamectin (Insecticide)													
Acephate (Insecticide)													
Acetamiprid (Insecticide)													
Afidopyropen (Insecticide)													
Bifenthrin (Insecticide)													
Buprofezin (Insecticide)													
Carbaryl (Insecticide)													
Chlorantraniliprole (Insecticide)													
Cyantraniliprole (Insecticide)													
Cyfluthrin (Insecticide)													
Deltamethrin (Insecticide)													
Dinotefuran (Insecticide)													
Flonicamid (Insecticide)													
Flupyradifurone (Insecticide)													
Halofenozide (Insecticide)													
Imidacloprid (Insecticide)													
lambda-Cyhalothrin (Insecticide)													
Permethrin (Insecticide)													
Pyriproxyfen (Insecticide)													
Spirotetramat (Insecticide)													
Thiamethoxam (Insecticide)													
Worker Activities	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Comments**

REFERENCES

USDA, National Agricultural Statistics Service. (2001). Census of Horticultural Specialties. 1988.

Alappat B., Alappat J. (2020) Anthocyanin Pigments: Beyond Aesthetics. Molecules 25. DOI: 10.3390/molecules25235500.

Appleton B.L., Orband J., Bartkus K. (2009) Pruning Crapemyrtles.

Beeson Jr R.C., Haydu J. (1995) Cyclic microirrigation in container-grown landscape plants improves plant growth and water conservation. Journal of Environmental Horticulture 13:6-11.

Beeson Jr R.C., Newton R. (1992) Shoot and root responses of eighteen southeastern woody landscape species grown in cupric hydroxide-treated containers. Journal of Environmental Horticulture 10:214-217.

Bilderback T. (2000) Pine bark storage and handling. Raleigh: North Carolina State University.

Bilderback T. (2017) Substrates for Plants Grown in BIG CONTAINERS, N.C. Cooperative Extension.

Blake J.H., Doubrava N., Gorsuch C.S., Scott J.M., Williamson J. (2021) Crape Myrtle Diseases & Insect Pests, in: C. C. Extension (Ed.), Home & Garden Information Center.

Boyer C.R., Gilliam C.H., Fain G.B., Gallagher T.V., Allen Torbert H., Sibley J.L. (2009) Production of woody nursery crops in clean chip residual substrate. Journal of Environmental Horticulture 27:56-62.

Braman S.K., Chappell M., Chong J.-H.J.C., Fulcher A., Gauthier N.W., Klingeman W.E., Knox G., LeBude A., Neal J., White S., Adkins C., Derr J., Frank S., Hale F., Hand F.P., Marble C., Williams-Woodward J., Windham A. (2015) Pest Management Strategic Plan for Container and Field-Produced Nursery Crops in FL, GA, KY, NC, SC, TN, and VA: Revision 2015, Southern Region IPM Center, Raleigh, NC. pp. 236 p.

Bush E.A. (2018) Botryosphaeria canker and dieback of trees and shrubs in the landscape.

Buxton B. (2017) Crape Myrtle with NO Blooms, UCANR, UNDER THE SOLANO SUN.

Cabrera R.I. (2009) Revisiting the salinity tolerance of crapemyrtles (Lagerstroemia spp.). Arboriculture & Urban Forestry 35:129-134.

Cabrera R.I., Devereaux D.R. (1999) Crape myrtle post-transplant growth as affected by nitrogen nutrition during nursery production. Journal of the American society for Horticultural science 124:94-98.

Cambre K., Sharpe K.W. (2018) Crape Myrtle Care.

Cantliffe D.J. (1993) Pre-and postharvest practices for improved vegetable transplant quality. HortTechnology 3:415-418.

Chappell M.R., Braman S.K., Williams-Woodward J., Knox G. (2012) Optimizing Plant Health and Pest Management of Lagerstroemia spp. in Commercial Production and Landscape Situations in the Southeastern United States: A Review. Journal of Environmental Horticulture 30:161-172. DOI: 10.24266/0738-2898.30.3.161.

Chase A.R. (1992) Bacterial Disease Control on Ornamentals using Aliette, Kocide, Greenshield and ASC-66825 University of Florida, Central Florida Research and Education Center-Apopka.

Cooley J. (2013) Review of Root Manipulation in Containers©. Proceedings of the International Plant Propagators Society-2013 1055:169-174.

Dihingia S., Saud B.K. (2016) Effect of type and time of pruning on flowering behaviour of Crape Myrtle (Lagerstroemia indica L.) in sub-tropical landscape. Research on Crops 17:829-833.

Doubrava N., Scott J.M., Blake J.H., Gorsuch C.S., Williamson J. (2021) CRAPE MYRTLE DISEASES & INSECT PESTS.

Dyer A.G., Jentsch A., Burd M., Garcia J.E., Giejsztowt J., Camargo M.G.G., Tjørve E., Tjørve K.M.C., White P., Shrestha M. (2020) Fragmentary Blue: Resolving the Rarity Paradox in Flower Colors. Front Plant Sci 11:618203. DOI: 10.3389/fpls.2020.618203.

Egolf D.R. (1987) 'Biloxi','Miami', and 'Wichita'Lagerstroemia. HortScience 22:336-338.

Fare D.C., Gilliam C.H., Keever G.J., Olive J.W. (1994) Cyclic irrigation reduces container leachate nitrate-nitrogen concentration. HortScience 29:1514-1517.

Fields J.S., Criscione K.S., Edwards A. (2022) Single-screen bark particle separation can be used to engineer stratified substrate systems. HortTechnology 32:391-397.

Franco G.M. (2020) Impacts of commercial biopesticides on crapemyrtle bark scale (Acanthococcus lagerstroemiae) and beneficial insects, Louisiana State University and Agricultural & Mechanical College.

Franco G.M., Chen Y., Doyle V.P., Rehner S.A., Diaz R. (2022) Mortality of the crapemyrtle bark scale (Hemiptera: Eriococcidae) by commercial biopesticides under greenhouse and field conditions. Biological Control 175:105061.

Frank S., Bambara S., Baker J. (2019a) Ambrosia Beetle Pests of Nursery and Landscape Trees, in: N. S. Extension (Ed.), Entomology Insect Notes, NC State Extension.

Frank S., Bambara S., Baker J. (2019b) Crapemyrtle Aphid. NC State Extension.

Funderburk C., Funderburk J., Tyler-Julian K., Srivastava M., Knox G., Andersen P., Adkins S. (2015) Population Dynamics of Frankliniella bispinosa (Thysanoptera: Thripidae) and the Predator Orius insidiosus (Hemiptera: Anthocoridae) as Influenced by Flower Color of Lagerstroemia (Lythraceae). Environmental Entomology 44:668-679. DOI: 10.1093/ee/nvv057.

Funderburk C., Funderburk J., Tyler-Julian K., Srivastava M., Knox G., Andersen P., Adkins S. (2015) Population Dynamics of Frankliniella bispinosa (Thysanoptera: Thripidae) and the Predator Orius insidiosus (Hemiptera: Anthocoridae) as Influenced by Flower Color of Lagerstroemia (Lythraceae). Environmental Entomology 44:668-679. DOI: 10.1093/ee/nvv057.

Garber M.P., Ruter J.M., Midcap J.T., Bondari K. (2002) Survey of container nursery irrigation practices in Georgia. HortTechnology 12:727-731.

Gilman E.F., Black R.J. (2005) Pruning landscape trees and shrubs Florida Cooperative Extension Service, Institute of Food and AgriculturaL Sciences.

Gilman E.F., Knox G. (2005) Pruning type affects decay and structure of crapemyrtle. Journal of Arboriculture 31:48-53.

Gilman E.F., Knox G.W., Neal C.A., Yadav U. (1994) Microirrigation affects growth and root distribution of trees in fabric containers. HortTechnology 4:43-45.

Gilman E.F., Watson D.G., Klein R.W., Koeser A.K., Hilbert D.R., McLean D.C. (2019) Lagerstroemia speciosa: Queens Crape Myrtle, UF/IFAS Extension.

Gu M., Merchant M., Robbins J., Hopkins J. (2014) Crape myrtle bark scale: A new exotic pest. EHT-049 3.

Harp D., Chretien K., Brown M., Jones C., Lopez-Serrano J. (2021) Landscape Performance of Ebony Crepe Myrtle Cultivars in Low-input Landscapes in North-central Texas. HortTechnology 31:234-240.

Harris J.A. (1914) On a Chemical Peculiarity of the Dimorphic Anthers of Lagerstroemia indica, with a Suggestion as to its Ecological Significance. Annals of Botany 28:499-507. DOI: https://doi.org/10.1093/oxfordjournals.aob.a089517.

Harrison H. (2006) Pruning and Fertilizing Crape Myrtles, LSU AgCenter.

Hayat M., Alam S.M., Agarwal M.M., Shafee S.A. (1975) Taxonomic survey of encyrtid parasites (Hymenoptera: Encyrtidae) in India Aligarh Muslim University.

Hayns C.L., Lindstrom O.M., Dirr M.A. (1991) Pruning Effects on the Cold Hardiness ofHaggerston Gray'Leyland Cypress andNatchez'Crape Myrtle. HortScience 26:1381-1383.

Jiang N., Xu H. (1998) Observation on Eriococcus lagerostroemiae Kuwana. Journal of Anhui Agricultural University 2:142-144. (in Chinese).

Joseph S.V., Hudson W., Pugliese P.J. (2019) Granulate ambrosia beetle: Biology and management. University of Georgia: Athens, GA, USA.

Kim S.-C., Graham S.A., Graham A. (1994) Palynology and pollen dimorphism in the genus Lagerstroemia (Lythraceae). Grana 33:1-20. DOI: https://doi.org/10.1080/00173139409427452.

Knight P.R., Eakes D.J., Gilliam C.H., Tilt K.M. (1993) Propagation container size and duration to transplant on growth of two Ilex species. Journal of Environmental Horticulture 11:160-162.

Knox G.W. (2006) New Red-Flowered Crape Myrtles: ENH1019/EP256, 5/2006. EDIS 2006.

Knox G.W., Gilman E.F. (2010) Crapemyrtle Pruning: ENH1138/EP399, 9/2009. EDIS 2010.

Lau P., Bryant V., Ellis J.D., Huang Z.Y., Sullivan J., Schmehl D.R., Cabrera A.R., Rangel J. (2019) Seasonal variation of pollen collected by honey bees (Apis mellifera) in developed areas across four regions in the United States. PLoS One 14:e0217294. DOI: https://doi.org/10.1371/journal.pone.0217294.

Layton M.B., Pierce J., Grisham J., Musser F. (2022) Efficacy and Duration of Control of Soil-Applied Insecticides Against Crapemyrtle Bark Scale, 2020–2021. Arthropod Management Tests 47:tsac016.

LeSage L. (1995) Revision of the costate species of Altica Müller of North America north of Mexico (Coleoptera: Chrysomelidae). The Canadian Entomologist 127:295-411.

Marble S.C., Fain G.B., Gilliam C.H., Runion G.B., Prior S.A., Torbert H.A., Wells D.E. (2012) Landscape establishment of woody ornamentals grown in alternative wood-based container substrates. Journal of Environmental Horticulture 30:13-16.

Martin C.A., Ruter J.M. (1996) Growth and foliar nutrient concentrations of crape myrtle in response to disparate climate and fertilizer placement in large nursery containers. Journal of Environmental Horticulture 14:9-12.

Marwah P., Zhang Y.Y., Gu M. (2021) Investigating producers' preferences for crapemyrtle and their perceptions regarding crapemyrtle bark scale. Horticulturae 7:146.

Meerow A.W., Ayala-Silva T., Irish B.M. (2015) Lagerstroemia speciosa 'Big Pink': An Improved Pink-flowered Queen's Crape Myrtle. HortScience horts 50:1593-1594. DOI: 10.21273/hortsci.50.10.1593.

Million J.B., Yeager T.H. (2019) Testing an automated irrigation system based on leaching fraction testing and weather in a container nursery. HortTechnology 29:114-121.

Million J.B., Yeager T.H. (2021) Use of routine leaching fraction testing to guide irrigation at a container nursery. Journal of Environmental Horticulture 39:108-114.

Montague T., McKenney C., Maurer M., Winn B. (2007) Influence of irrigation volume and mulch on establishment of select shrub species. Arboriculture and Urban Forestry 33:202.

Monteiro F.P., Ogoshi C., Mallmann G. (2022) Chemical control of bacteria Xanthomonas hortorum pv. gardneri and Xanthomonas euvesicatoria pv. perforans in vitro. Plant Pathology & Quarantine 12:133-146.

Moore K., Bradley L.K. (2018) North Carolina Extension gardener handbook NC State Extension, College of Agriculture and Life Sciences, NC State University

Nepi M., Guarnieri M., Pacini E. (2003) "Real" and feed pollen of Lagerstroemia indica: ecophysiological differences. Plant Biology 5:311-314. DOI: https://doi.org/10.1055/s-2003-40797.

NeSmith D.S., Duval J.R. (1998) The effect of container size. HortTechnology 8:495-498.

Niemiera A.X. (2018) Crapemyrtle (Lagerstroemia indica).

Ong K. (2004) Powdery mildew on crape myrtles. Texas A&M AgriLife Ext. Service. PLPA 103.

Polomski B., Shaughnessy D. (2006) Crape Myrtle Pruning.

Pounders C., Reed S., Pooler M. (2006) Comparison of self-and cross-pollination on pollen tube growth, seed development, and germination in crapemyrtle. HortScience 41:575-578. DOI: https://doi.org/10.21273/HORTSCI.41.3.575.

Pounders C.T., Blythe E.K., Fare D.C., Knox G.W., Sibley J.L. (2010) Crapemyrtle genotype× environment interactions, and trait stability for plant height, leaf-out, and flowering. HortScience 45:198-207.

Riddle T.C., Mizell III R.F. (2016) Use of crape myrtle, Lagerstroemia (Myrtales: Lythraceae), cultivars as a pollen source by native and non-native bees (Hymenoptera: Apidae) in Quincy, Florida. Florida Entomologist:38-46. DOI: http://dx.doi.org/10.1653/024.099.0108.

Schluckebier J.G., Martin C.A. (1997) Effects of above-ground pot-in-pot (PIP) placement and humic acid extract on growth of crape myrtle. Journal of Environmental Horticulture 15:41-44.

Schultz P.B., Szalanski A.L. (2019) Hypericum kalmianum (St. Johnswort) Confirmed as a New Host of the Crapemyrtle Bark Scale in Virginia, USA. Journal of Agricultural Urban Entomology 35:12-15.

Shreckhise J.H., Owen J.S., Eick M.J., Niemiera A.X., Altland J.E., Jackson B.E. (2020) Dolomite and micronutrient fertilizer affect phosphorus fate when growing crape myrtle in pine bark. HortScience 55:832-840.

Shreckhise J.H., Owen J.S., Niemiera A.X., Altland J.E. (2022) Growth and Quality Response of Four Container-grown Nursery Crop Species to Low-phosphorus Controlled-release Fertilizer. HortTechnology 32:447-458.

Smith T.L., Paul. (2014) Field Nurseries: Nutrient Management, Best Management Practices (BMPs) for Nursery Crops, University of Massachusetts, Amherst.

Soliman A.S., Shanan N.T. (2017) The role of natural exogenous foliar applications in alleviating salinity stress in Lagerstroemia indica L. seedlings. Journal of Applied Horticulture 19:35-45.

Suh S.-J. (2019) Notes on some parasitoids (Hymenoptera: Chalcidoidea) associated with Acanthococcus lagerstroemiae (Kuwana)(Hemiptera: Eriococcidae) in the Republic of Korea.

Taubenhaus J.J., Ezekiel W.N. (1936) A Rating of Plants with Reference to their Relative Resistance or Susceptibility to Phymatotrichum Root Rot. Texas FARMER Collection.

Tilt K., Gilliam C., Olive J., Carden E. (1992) Growth of container-grown trees transplanted from the field or grow-bags. HortTechnology 2:415-417.

UMass. (2023) Soil Testing, University of Massachusetts Extension.

USDA A. (2015) Managing the Japanese Beetle: A Homeowner's Handbook, in: USDA (Ed.).

USDA N. (2014b) Contour Buffer Strips (Ac.) (332) Conservation Practice Standard, in: N. R. C. Service and U. S. D. O. AGRICULTURE (Eds.).

USDA, National Agricultural Statistics Service. (2009). Census of Horticultural Specialties. 2009."

USDA, National Agricultural Statistics Service. (2014). Census of Horticultural Specialties. 2014.

USDA, National Agricultural Statistics Service. (2019). Census of Horticultural Specialties. 2019

Vafaie E., Gu M. (2019) Insecticidal control of crapemyrtle bark scale on potted crapemyrtles, Fall 2018. Arthropod Management Tests 44:tsz061.

Vafaie E., Merchant M., Xiaoya C., Hopkins J.D., Robbins J.A., Chen Y., Gu M. (2020) Seasonal Population Patterns of a New Scale Pest, Acanthococcus lagerstroemiae Kuwana (Hemiptera: Sternorrhynca: Eriococcidae), of Crapemyrtles in Texas, Louisiana, and Arkansas.1. Journal of Environmental Horticulture 38:8-14. DOI: 10.24266/0738-2898-38.1.8.

Vafaie E.K. (2021) Insecticide Efficacy Against Crapemyrtle Bark Scale (Acanthococcus lagerstroemiae) in Containerized Production, 2020. Arthropod Management Tests 46:tsab116.

Vafaie E.K., Knight C.M. (2017) Bark and systemic insecticidal control of Acanthococcus (= Eriococcus) lagerstroemiae (crapemyrtle bark scale) on landscape crapemyrtles, 2016. Arthropod Management Tests 42:tsx130.

Wade G.L., Williams-Woodward J. (2009) Crape myrtle culture.

Wang Y., Zhang Y.-Z. (2014) A taxonomic study of Chinese species of the insidiosus group of Metaphycus (Hymenoptera, Encyrtidae). ZooKeys:49.

Wang Z., Chen Y., Diaz R. (2016a) The cactus lady beetle: a voracious predator of scale insects. Bug Biz, Ag Center, LSU 3480:11-15.

Wang Z., Chen Y., Gu M., Vafaie E., Merchant M., Diaz R. (2016b) Crapemyrtle bark scale: a new threat for crapemyrtles, a popular landscape plant in the U.S. Insects 7:78.

Wright R.D., Browder J.F., Jackson B.E. (2006) Ground pine chips as a substrate for container-grown woody nursery crops. Journal of Environmental Horticulture 24:181-184.

Wu B., Chun E., Xie R., Knox G.W., Gu M., Qin H. (2022a) Real-Time Feeding Behavior Monitoring by Electrical Penetration Graph Rapidly Reveals Host Plant Susceptibility to Crapemyrtle Bark Scale (Hemiptera: Eriococcidae), Insects.

Wu B., Xie R., Gu M., Qin H. (2022b) Green lacewing Chrysoperla rufilabris (Neuroptera: Chrysopidae) is a potential biological agent for crapemyrtle bark scale (Hemiptera: Eriococcidae) pest management. Technology in Horticulture 2:1-5.

Xie R., Wu B., Gu M., Jones S.R., Robbins J., Szalanski A.L., Qin H. (2021) Confirmation of New Crapemyrtle Bark Scale (Acanthococcus lagerstroemiae) Hosts (Spiraea and Callicarpa) through DNA Barcoding. HortScience 56:1549-1551. DOI: 10.21273/HORTSCI16151-21.

Xie R., Wu B., Gu M., Qin H. (2022) Life Table Construction for Crapemyrtle Bark Scale (Acanthococcus lagerstroemiae): The Effect of Different Plant Nutrient Conditions on Insect Performance. Scientific Reports 12.

Xie R., Wu B., Gu M., Qin H. (2023) Biological Parameters of Crapemyrtle Bark Scale (Acanthococcus lagerstroemiae) Differ When Reared on Different Crapemyrtle Hosts. HortScience 58:559-567. DOI: 10.21273/HORTSCI17009-22.

Yeager T., Gilliam C., Bilderback T.E., Fare D., Niemiera A., Tilt K. (1997) Best management practices: Guide for producing container-grown plants. Southern Nursery Association. Atlanta, GA 7.

Yu C., Lian B., Fang W., Guo A., Ke Y., Jiang Y., Chen Y., Liu G., Zhong F., Zhang J. (2021) Transcriptome-based analysis reveals that the biosynthesis of anthocyanins is more active than that of flavonols and proanthocyanins in the colorful flowers of Lagerstroemia indica. Biologia Futura 72:473-488. DOI: 10.1007/s42977-021-00094-0.

Zajicek J.M., Steinberg S.L., McFarland M.J. (1991) Effect of the Amount of Dormant Pruning on Growth and Water Use of Containerized Crape Myrtle (Lagerstroemia× Fauriei 'Tuscarora'). Journal of Environmental Horticulture 9:88-91.

Zeya S.B., Hayat M. (1993) A review of the Indian species of Metaphycus (Hymenoptera; Encyrtidae). Oriental Insects 27:185-209.

Zhang Y.-Z., Huang D.-W. (2001) Two new Encyrtid parasites (Hymenoptera: Chalcidoidea) from China. Oriental Insects 35:311-319.

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