PEST MANAGEMENT STRATEGIC PLAN FOR STRAWBERRY IN NORTH CAROLINA, VIRGINIA, SOUTH CAROLINA, GEORGIA, AND FLORIDA

SOURCE

Source Date	07/27/2024
Workshop Date	11/08/2023
Workshop Location	Charlotte, NC (11/8/2023) and Savannah, GA (1/11/2024)
Region	Southern
Type	Pest Management Strategic Plan
Title	Pest Management Strategic Plan for Strawberry in North Carolina, Virginia, South Carolina, Georgia, and Florida
Preview Sheet	
PDF Document	https://ipmdata.ipmcenters.org/documents/pmsps/FLGANCSCVAStrawberryPMSP2024-12.19.2024.pdf
Setting/Crop	Strawberry
States	Florida, Georgia, North Carolina, South Carolina, Virginia
Editors	Lacey Belanger Charlotte Dovey Lorena Lopez
Contacts	Lorena Lopez, North Carolina State University, llopezq@ncsu.edu
Contributors	Thomas Addison, H&A Farms Mariko Archambault, Organzo Steven Arthurs, Biobee Michael Bael, Kildee Farms Cameron Beggs, Beggs Berry Farms Luis Benavides, H&A Farms Ashley Best, University of Georgia Nathan Boyd, University of Florida Phil Brannen, University of Georgia William Cline, North Carolina State University Jeff Cook, University of Georgia Nancy Corahan, The Ivy Place Vanessa Davis, ISK Bioscience Jim Driver, Biological Applied Research, Inc. Dorothy Dupree, Farm to School Education Specialist Drew Ehils, Jaemur Farms Wael Elwakil, University of Florida Julius Fajardo, USDA Office of Pest Management Policy (OPMP) Gina Fernandez, North Carolina State University Roy Flanagan, Virginia Polytechnic Institute & State University (Virginia Tech) Mark Freeman, BioWorks Pierson Geyer, Agriberry Farm Jimmy Hammond, Lynn's Berries Corey Harmon, Titan Farms Chad Holliman, Fitzgerald Fruit Farms Patrick Johnson, Nanih Farm and Garden

	Whit Jones, Cottle Farms Katie Kellam, Organzo Sriyanka Lahiri, University of Florida James Lee, Buckwheat Farm Hannah Levenson, North Carolina State University Clemen Oliveira, Certis Biologicals Dennis Poythiesse, Poythiesse Farms Temi Poythiesse, Poythiesse Farms William Renz, Frankin Farms Whitney Richardson, University of Georgia Bob Rouse, Bob Rouse Agri. LLC Zilfina Rubio, University of Georgia Jayesh Samtani, Virginia Polytechnic Institute & State University (Virginia Tech) Guido Schnabel, Clemson University Erich Schoeller, University of Georgia Eil Sikora, Auburn University Dawn Smith, Dawn Smith Farms Zachary Snipes, Clemson University Harry Stacey, HS Farm Emmanuel Torres, North Carolina State University Lanier Warbington, Warbington Farms Walt Webb, Lewis Nursery & Farms Josh White, Cajenn Farms Austin Wrenn, Wrenn Farms
Funding	USDA NIFA
Description	The Pest Management Strategic Plan (PMSP) for Strawberries in the Southern Region outlines priorities for research, regulation, and outreach to guide activities such as EPA registration of pesticides, government and other agencies' allocation of funds for research, scientists in their research endeavors, and other activities related to solving pest management issues. Growers, industry representatives, specialists, regulators, and processors participated in this event to update this important document. Included in the 2024 PMSP for Strawberries are the states of Virginia, North Carolina, South Carolina, Georgia, and Florida. To ensure information was collected from the entire region, two-session workshops were held. The first session discussed practices and priorities for Virginia and North Carolina. The second session discussed practices and priorities for the remaining states, Florida, Georgia, and South Carolina. The Southern IPM Center supported this two-session workshop. Workshop session 1: 2023 Southeast Strawberry Expo, Charlotte, NC Workshop session 2: 2024 Southeast Regional Fruit and Vegetable Conference, Savannah, GA
Citation	Lopez, Lorena. (2024). *Pest Management Strategic Plan for Strawberry in North Carolina,Virginia*. National IPM Database. https://ipmdata.ipmcenters.org/source_report.cfm?view=yes&sourceid=2489

EXECUTIVE SUMMARY

This PMSP is for Virginia, North Carolina, South Carolina, Georgia, and Florida. In November 2023, twenty growers, University Extension Specialists, industry representatives, and USDA's Office of Pest Management Policy plant pathologists met in Charlotte, NC, to collect the PMSP data related to North Carolina and Virginia. In January 2024, thirty-eight additional growers, University Extension Specialists, and industry representatives met in Savannah, GA, to collect the PMSP data related to South Carolina, Georgia, and Florida. This PMSP for strawberry production in the southeast of the U.S. was developed with the pooled data from these two workshop sessions. These states are all members of the Southern Region Small Fruit Consortium (SRSFC). The mission of the SRSFC is to develop collaborative efforts at various sites across the region between small fruit growers and grower organizations, industries and service organizations allied with and/or serving small fruit growers, agricultural extension programs and research stations working together to enhance the development of the small fruit industries in the region. The SRSFC University partners include Auburn University, University of Arkansas, University of Georgia, Louisiana State University, Mississippi State University, North Carolina State University, Clemson, University of Tennessee, and Virginia Polytechnic Institute and State University.

The southeast region includes two of the top three strawberry-producing states in the U.S. Florida ranks No. 2, producing about 9% of the nation's strawberries between 2021 and 2023, and more than 14,100 acres valued at $511 million dollars in 2023. Despite a substantial difference in production and acreage, North Carolina ranks No. 3 among the largest strawberry-producing states, with ~2,000 acres valued at $23.4 million and grown in all 100 counties (2023). The remaining states have a range of producing acres between 200 (VA) up to 700 (SC), mostly family-owned and dedicated to pick-your-own (PYO) systems. These continue to be a valuable source of income for small to medium size regional producers. Similar insect and mite pests challenge strawberry growers in the region. However, pest management programs differ immensely throughout the region, especially in Florida, where more large-scale and industrialized production exists. Additionally, Florida is the only state in the region where the invasive pest, chilli thrips, has established and quickly became the most damaging pest in strawberries. These workshop sessions aimed to develop a comprehensive list of pests, biological control agents, and chemical and cultural control tactics used in the region. The priorities identified include 1) Regulatory: Retain chemistries valuable for insect and mite pests, as well as diseases; 2) Research: Develop/Identify resistant cultivars to Neopestalotiopsis; 3) Education: Develop early-detection tools to identify invasive thrips infestations in strawberry plantings outside Florida. Grower participation was vital to developing this document. With their contributions, we are presenting the current challenges and needs of the strawberry industry in the southeast region of the U.S.

In addition to the input from the participants of the PMSP meeting, this online document cited sections from the Southern Region Small Fruit Consortium 2024 Strawberry IPM guide. This document was a collaborative effort by many individuals listed above. Special thanks also go to the Southern IPM Center for funding to support this project.

Key Pests are listed in alphabetical order:

Key Pests

Insects

Chilli thrips (*Scirtothrips dorsalis*)
Sap beetles, species complex
Spotted-wing drosophila (swd) (*Drosophila suzukii*)
Western flower thrips (wft) (*Frankliniella occidentalis*)

Pathogens

Anthracnose fruit rot (*Colletotrichum nymphaeae*)
Gray mold (*Botrytis cinerea*)
Leaf spot and fruit rot (*Neopestalotiopsis*)
Powdery mildew (*Podosphaera macularis*)

Weeds

Annual grasses
Black medic (*Medicago lupulina*)
Carolina geranium (*Geranium carolinianum*)
Common ragweed (*Ambrosia artemisiifolia*)
Curly dock (*Rumex crispus*)
Goosegrass (*Eleusine indica*)
Primrose, cutleaf evening (*Oenothera laciniata*)
Yellow and purple nutsedge

Nematodes

Root-knot nematode (*Meloidogyne spp.*)
Sting nematode (*Belonolaimus longicaudatus*)

Mites

Cyclamen mite (*Phytonemus pallidus*)
Twospotted spider mite (tssm) (*Tetranychus urticae*)

Wildlife

Deer

Critical Priorities

Education	Thrips pest species are not usually differentiated for pest management in most of the region's strawberries (except for FL). However, invasive thrips pests have made thrips identification necessary to improve control. Thus, pest identification tools, injury and damage symptom recognition, and educational resources are needed. Management resources involving biological control options for thrips management are also needed.
Education	The increased incidence of herbicide resistance (e.g., goosegrass, and ragweed parthenium) requires the development of herbicide resistance management plans for

	strawberries, which we have not really worried about in the past.
Education	Development of pest identification guides for thrips, particularly chilli thrips, easy-to-use posters for extension offices, images, life cycles, injury, and damage educational resources. These guides should help differentiate native and invasive thrips species.
	Keeping tools such as the MyIPM App up to date.
	Early detection, ample distribution, and timely pest alerts for emerging diseases, insects (e.g., chilli thrips, *Scirtothrips dorsalis*, pepper *Thrips parvispinus*), and mites.
	Decision trees for disease and pest management, including pesticide rotation options combining multiple IRAC and FRAC classes.
Education	Knowledge about existing disease and pest predictive models and how to use them is needed.
Education	Molecular diagnostic services for different insect and mite pests.
Education	IPM Workshops/Field Days to wrap up everything from identification to control methods.
Education	Resources for cyclamen mite identification and management, as well as guidelines on how to use pesticides with predatory mites (natural enemy and pesticide compatibility resources), are needed.
Regulatory	Labor is a major limitation for growers. There is a need to facilitate more H2A employees and permits for housing placements for H2A in FL and VA.
Regulatory	There are no registered herbicides for purple and yellow nutsedge control. Need for more I-R4 work focused on weed control, including use of bicyclopyrone.
Regulatory	Facilitate Clean Plant Initiatives free of diseases and pests, transparency regarding the treatments nurseries use prior to shipping, clean certification, and the release of information on chemical use for plant material.
	Incentives to implement alternative treatments to pesticides (e.g., steam or hot water treatments, UV light, etc.) for clean plants in nurseries are needed.
Regulatory	Retaining chemistries (i.e., Captan and Thiram), adding strawberries to other labels (supplemental labels) for resistant management purposes, and strengthening the relationship with IR-4 are needed.
Regulatory	More communication of regulatory updates on the registration of pesticides and ESA (Endangered Species Act).
Regulatory	Due to the variability of high tunnel implementation, a clear definition of high tunnel versus greenhouse pesticide registrations is non-existent. Additionally, many pesticide labels are not very clear about restrictions or permissions for use in greenhouses. There is an urgent need to establish guidelines for high tunnels versus greenhouse pesticide use and improve label guidelines for specific greenhouse use.
Research	Establishment status of chilli thrips and pepper thrips in the region (except for FL). Additionally, there is a need for more studies to control these new/emerging pests and monitoring, evaluating any variety resistance, or preference, and potential resistance development.
Research	Breed for host plant pest and disease resistance, focusing on resistance to Neopestalotiopsis.
Research	Emergence of Fusarium is a major concern (especially for those getting plants from CA). Incidence measures and protocols to test plant materials for fungal diseases are needed.
	Screening and assessment of new fungicides and phytotoxicity for pesticide mixes, especially for use during propagation, dipping, etc., are needed.
Research	Evaluating the effect of weed competition on yield, scheduling weed removal properly to avoid increasing the seed bank, evaluating more herbicide products, maintaining current chemistries, developing all-season weed management plans, and management methods for organic production.
Research	Increase precision agriculture tools to facilitate and/or improve all cultivation practices. Additionally, disease and pest management programs tailored to varietal differences need to be studied.
Research	Cyclamen mites are becoming recurrent in VA, NC, and SC. They usually originate from nurseries, and growers have limited pesticide products that are effective against this pest. This is mostly because insecticides do not reach deep into the crown, where the mites are found. Thus, there is a need for testing practical alternative management methods at the nursery and grower levels, as well as assessment of biological control options against cyclamen mites and varietal susceptibility.
Research	More chemistries and resistance management.
Research	Pesticide compatibility with biological control methods for pest and disease management, and availability of bioinsecticides effective against insect pests.
Research	Pesticide compatibility with biological control methods for insect and mite management.

CROPS / SETTINGS

Small Scale Production

In Virginia and Georgia, strawberries are grown in similar production systems. In these states, the strawberry industry is mainly composed of open-field small farms (1-3 acres) devoted to direct consumer markets or pick-your-own (PYO) systems, with 20-40% pre-picked fruit usually sold on farms or at roadside stands, some with wholesale market contracts. Most are family farms with multiple generations of farming experience, and they grow a combination of fruits, vegetables, wood, and field crops in addition to strawberries. In South Carolina, more and more larger farms, especially those focused on peach production, are starting to diversify with strawberries. Harvest activities in Virginia, South Carolina, and Georgia traditionally occur in late April through early June (6-8 weeks).

Medium and Large Scale Production

While most of the states in the region include strawberries as a staple fruit crop in small diversified farms, mostly for PYO systems, Florida produces strawberries in medium to large farms (50 to hundreds of acres) with pre-pick operations and for fresh markets. Strawberries are typically planted between September and October and harvested from December until early April, with a peak harvest between December and February.

North Carolina strawberries come from various farm sizes, from small family-owned farms (<50 acres) to medium and large farms ranging from 50 to ~1,000 acres of strawberries. Most medium-sized to large-scale farmers have a combination of oped-field and protected strawberry production to extend their harvest time. Harvest follow the same time as Florida in protected structures (early systems known as spring production), and the same times as the rest of the season for open-field production (late systems or summer production).

Production Areas Within States

Virginia has an average yield of 14,000-18,000 lb/acre, and most of the production is concentrated in the Hampton Roads region (Virginia Beach and Chesapeake area). The most concentrated areas of strawberry farms are in the Chesapeake/Virginia Beach area. Small to medium patches of berry production are scattered throughout the state, including the outskirts of the cities of Richmond and Charlottesville and surrounding the Washington D.C. area.

Strawberry production in **South Carolina** is distributed in 26 counties. The highest acreage is concentrated in Spartanburg County. Only 21 acres have been reported as organic, and 10 acres are dedicated to processed products. Strawberries are produced across all 100 counties in **North Carolina**.

Despite growing only approximately 200 acres annually, **Georgia** is known for its high-quality strawberries. About 88 farms grow them in the southern part of the state.

Ninety-five percent of **Florida's** commercial strawberry production acreage is located in the west central counties of Hillsborough and Manatee, with the remainder in several other southwestern counties.

Crop Stages

Order	Crop Growth	Stage	Days After Emergence
0	Sprout	Nursery	0
1	Seedling	Planting	0-20 (FL); 0-45 (remaining states)
2	Vegetative	Dormant	No true dormant stage (FL); 45-115 (remaining states)
3	Vegetative	Vegetative Growth	20-30 (FL); 115-175 (remaining states)
4	Flowering	Preharvest	> 30 (FL); 115-175 (remaining states)
5	Flowering	Harvest	60-130 (FL); 175-220 (remaining states)

6	Flowering	Post Harvest	> 60 (FL); > 175 (remaining states)

Crop Cycles Per Year: 1

BACKGROUND

The U.S. is the second-largest producer of strawberries in the world after China. More than one million tons of strawberries are produced annually in the U.S., valued between $2-3 billion dollars, and showing the highest yield worldwide (56.4 tons/ha) after Mexico. The highest strawberry-producing states are California (~90% fresh annual production), Florida (~9% fresh annual production), and North Carolina (primarily for fresh production). Most of the strawberry production revenue is generated from fresh fruit sales through direct markets, from grower to consumer (pick-your-own (PYO), produce stands, farmers markets), or direct sales (grocery stores, wholesale providers, restaurants, retail bakery, etc.). The remainder of the market comprises frozen strawberry sales or processed strawberries for products like jams, syrups, yogurt, or ice cream. These products can be sold in the same market space as fresh strawberries.

The first PMSP for strawberries in the southern region was created in 2000. This document included FL, NC, SC, and VA. GA was not included, unfortunately. A PMSP for strawberries in FL was developed in 2003 and 2007. These documents are highly outdated, given the number of chemicals no longer permitted in strawberry production and the changes in the pest complexes around this crop in the region. Additionally, strawberry production in major producing states such as CA and FL doubled between 2000 and 2019. This is the first strawberry PMSP that includes all the southern coastal states, FL, GA, SC, NC, and VA. This document offers a significant update on the pre-existent PMSPs for strawberries in the region.

Pest Management

Arthropod pests, pathogens, and weeds are the biggest threats to strawberry production. They can affect the complete production cycle of strawberries resulting in inconsistent production stands and reduced yields, fruit quality, and post-harvest lifespan. For instance, invasive pests established in FL and emerging in GA, can infest strawberry seedlings as soon as 1-2 weeks after transplant in the field. Weeds compete for light, water, and nutrients and host diseases, viruses, and nematodes. This competition decreases plant vigor, yield, and crop quality. The industry has managed different pests and diseases through plastic mulches, fumigants, aerial sprays, and herbicides. Growers are also challenged by invasive and native arthropod pests such as thrips, spider mites, weevils, and Lygus bugs to a lesser extent.

Twospotted spider mite severe infestation in strawberry under high tunnels (Photo by L. Lopez).

Many pests and diseases live and grow in the soil environment. Similarly, the emergence of *Neopestalotiopsis* in the last decade is the disease of most concern in the region, causing significant yields annually, increasing disease management costs, and distress within the strawberry farming community.

Disease outbreak in Florida strawberry fields caused by the new Neopestalotiopsis sp. A, early stage symptoms; B, late stage symptoms; C, light to dark brown spots of different sizes developing from the margins; D, detail of leaf spots; and E, overall symptoms in the field (Baggio et al. 2020).

To reduce disease and pest populations, growers have historically relied on Methyl Bromide (MBrm) as their main soil fumigant to control many pathogens, pests, plant parasitic nematodes, and weeds. Agriculture was estimated to consume around 75% of the total amount of methyl bromide consumed. Despite its efficacy, MBrm was phased out in 2005 due to its effects as the main ozone layer depletant. With the phasing out of MBrm, the National Center for Food and Agricultural Policy estimated a loss of $120 million for strawberry production.

Researchers are focused on finding efficient alternatives to replace MBrm in controlling weeds and pathogens. MBrm alternatives include new chemicals, steam, solarization, anaerobic soil disinfection, plastic films, controlled environments, cover crops, and resistant cultivars. There is no one-size-fits-all solution for disease, pest, and weed management in soil-based systems, and a combination of methods may be useful for strawberry production.

Regulatory

The participants identified a total of eight regulatory priorities. The top five of these priorities are focused on:

1. Facilitating labor acquisition.
2. Promoting and regulating transparency of clean plant initiatives.
3. Retaining chemistries.
4. Improving communication and distribution of regulatory announcements.
5. Consolidate universal definitions and differences between high tunnel and greenhouse production.

PRIORITIES

The top five education, regulatory, and research priorities were identified during the two-session workshop. Additionally, other unranked priorities were identified and included in this document.

Overall, targeted pest management technologies are needed, with an emphasis on reduced pesticide inputs, mitigation of pesticide resistance, and addressing issues related to the Endangered Species Act. Additionally, the use of innovative technologies, such as AI and modeling, to detect, identify, map, and monitor pest incidence, was often highlighted as a research and education priority.

Category	Rank	Pest Type	Pest	Crop Stage	Priority	Outcome
Education	1	Insects	chilli thrips		Thrips pest species are not usually differentiated for pest management in most of the region's strawberries (except for FL). However, invasive thrips pests have made thrips identification necessary to improve control. Thus, pest identification tools, injury and damage symptom recognition, and educational resources are needed. Management resources involving biological control options for thrips management are also needed.	
Education	1	Weeds			The increased incidence of herbicide resistance (e.g., goosegrass, and ragweed parthenium) requires the development of herbicide resistance management plans for strawberries, which we have not really worried	

					about in the past.	
Education	2	Insects	chilli thrips		Development of pest identification guides for thrips, particularly chilli thrips, easy-to-use posters for extension offices, images, life cycles, injury, and damage educational resources. These guides should help differentiate native and invasive thrips species. Keeping tools such as the MyIPM App up to date. Early detection, ample distribution, and timely pest alerts for emerging diseases, insects (e.g., chilli thrips, *Scirtothrips dorsalis*, pepper *Thrips parvispinus*), and mites. Decision trees for disease and pest management, including pesticide rotation options combining multiple IRAC and FRAC classes.	
Education	3	Pathogens			Knowledge about existing disease and pest predictive models and how to use them is needed.	
Education	4	Insects			Molecular diagnostic services for different insect and mite pests.	
Education	5	Nematodes			The entire region has limited resources for nematode identification and management. Educational resources and activities are needed to help growers identify plant parasitic nematodes, learn how to sample for nematodes, and submit samples. More options for plant parasitic nematode management, specifically sting nematodes in FL organic production.	
Education	No Rank				IPM Workshops/Field Days to wrap up everything from identification to control methods.	
Education	No Rank	Insects			Resources related to pollinator protection and companion plants or flowering strips to promote natural enemies.	
Education	No Rank	Insects	Spotted-wing drosophila		More educational resources discussing how to implement SWD natural enemies, such as parasitoids and entomopathogenic nematodes.	
Education	No Rank	Mites	Cyclamen Mites		Resources for cyclamen mite identification and management, as well as guidelines on how to use pesticides with predatory mites (natural enemy and pesticide compatibility resources), are needed.	
Education	No Rank	Pathogens			More forecasting tools and awareness of these tools for growers.	
Education	No Rank	Pathogens			Information regarding dry calyx disorder.	
Regulatory	1				Labor is a major limitation for growers. There is a need to facilitate more H2A employees and permits for housing placements for H2A in FL and VA.	
Regulatory	1	Weeds			There are no registered herbicides for purple and yellow nutsedge control. Need for more I-R4 work focused on weed control, including use of bicyclopyrone.	
Regulatory	2	Pathogens			Facilitate Clean Plant Initiatives free of diseases and pests, transparency regarding the treatments nurseries use prior to shipping, clean certification, and the release of information on chemical use for plant material. Incentives to implement alternative treatments to pesticides (e.g., steam or hot water treatments, UV light, etc.) for clean plants in nurseries are needed.	
Regulatory	3	Pathogens			Retaining chemistries (i.e., Captan and Thiram), adding strawberries to other labels (supplemental labels) for resistant management purposes, and strengthening the relationship with IR-4 are needed.	
Regulatory	4				More communication of regulatory updates on the registration of pesticides and ESA (Endangered Species Act).	
Regulatory	5				Due to the variability of high tunnel implementation, a clear definition of high tunnel versus greenhouse pesticide registrations is non-existent. Additionally, many pesticide labels are not very clear about restrictions or permissions for use in greenhouses. There is an urgent need to establish guidelines for high tunnels versus greenhouse pesticide use and improve label guidelines for specific greenhouse use.	
Regulatory	No Rank	Insects			Rapid permissions for change in labels for different crops/commodities/pests (supplemental labels).	
Regulatory	No Rank	Wildlife	Deer		More wildlife permits for control methods against deer.	
Research	1	Insects	chilli thrips		Establishment status of chilli thrips and pepper thrips in the region (except for FL). Additionally, there is a need for more studies to control these new/emerging pests and monitoring, evaluating any variety resistance, or preference, and potential resistance development.	
Research	1	Pathogens			Breed for host plant pest and disease resistance, focusing on resistance to Neopestalotiopsis.	

Research	1	Pathogens	Fusarium wilts, blights, rots and damping-off		Emergence of Fusarium is a major concern (especially for those getting plants from CA). Incidence measures and protocols to test plant materials for fungal diseases are needed. Screening and assessment of new fungicides and phytotoxicity for pesticide mixes, especially for use during propagation, dipping, etc., are needed.	
Research	2	Weeds			Use of AI to detect, identify, map, and monitor incidence.	
Research	2	Weeds			Evaluating the effect of weed competition on yield, scheduling weed removal properly to avoid increasing the seed bank, evaluating more herbicide products, maintaining current chemistries, developing all-season weed management plans, and management methods for organic production.	
Research	3				Increase precision agriculture tools to facilitate and/or improve all cultivation practices. Additionally, disease and pest management programs tailored to varietal differences need to be studied.	
Research	4	Mites	Cyclamen Mites		Cyclamen mites are becoming recurrent in VA, NC, and SC. They usually originate from nurseries, and growers have limited pesticide products that are effective against this pest. This is mostly because insecticides do not reach deep into the crown, where the mites are found. Thus, there is a need for testing practical alternative management methods at the nursery and grower levels, as well as assessment of biological control options against cyclamen mites and varietal susceptibility.	
Research	5	Pathogens	Phytophthora Crown Rot	Planting	More chemistries and resistance management.	
Research	No Rank	Insects			Pesticide compatibility with biological control methods for pest and disease management, and availability of bioinsecticides effective against insect pests.	
Research	No Rank	Insects			More research including assessments of near wooded areas (board sprays, trapping) (alternate solutions) (sap beetles, clipper beetles, and stink bugs).	
Research	No Rank	Mites	Cyclamen Mites		Evaluation of best management spraying methods (pressure and volume needed) for cyclamen mites is needed to improve cyclamen mite management in nurseries and commercial farms. More chemistries registered against cyclamen mites.	
Research	No Rank	Mites			Pesticide compatibility with biological control methods for insect and mite management.	
Research	No Rank	Nematodes			Frequency of fumigation is needed, forecasting tools, reliable thresholds, and bionematicide options.	
Research	No Rank	Pathogens	Gray Mold		New modes of action for resistance management and high tunnel control methods.	

WORKER ACTIVITIES

Strawberry production follows a plasticulture system where plants are cultivated on raised beds covered with black plastic mulch. Workers build raised beds and fumigate them simultaneously. Beds are tightly lined with black plastic mulch, and drip irrigation systems are installed beneath the plastic 3-4 weeks after, depending on the fumigant applied.

During the planting phase in the fall, workers manually set strawberry plants (in most states) into the beds through slits in the plastic. Irrigation is usually stopped during the dormant stage in cold weather states in the region. To protect the plants from cold damage, especially in the northern regions of VA and NC, workers deploy floating row covers over the beds when frost is anticipated. In the remaining states, most growers use overhead irrigation for frost protection. This task requires timely response to weather forecasts. As the growing season progresses, labor is required to begin irrigating in the spring and apply fertilizers and other treatments through the drip system to promote healthy growth. Workers also monitor for pests and diseases, a crucial activity to ensure plant health and yield quality. Most worker activities include hand- and tractor-driven operations, such as cultivation, fertilization, operation of the fumigation rig, and laying drip tape. Harvest is conducted annually by workers in pre-picked fields or directly by costumers in PYO fields.

Fumigation

Land preparation consists of clearing the land of the previous crops and proceeding with soil fumigation (if practiced). Farmers who employ fumigation do it because they believe it offers advantages like reduced disease and weed issues during the growing season and possibly enhanced yields. Fumigation is conducted through injection systems during raised-bed construction or drip chemigation after plastic mulch layering.

Chloropicrin and 1,3-dichloropropene, and their mixes, are commonly applied to the soil using shank/knife injection in open-field annual hill plastic mulch production. Strawberry growers usually shank the fumigant to the planting bed in late August or early September (4-5 weeks before planting, depending on the label recommendation of the fumigant). The fumigant is injected 8-12 inches deep during bed preparation. Because specialized equipment is required to adequately apply most formulations of these products, a cost-effective alternative is the application of fumigants through the drip irrigation line. Fumigation efficiency is often dependent on the complete wetness of the planting bed. This is particularly challenging to achieve on coarse soils, typical in most vegetable production regions of VA and the southeastern U.S.

Chloropicrin is highly toxic against insects and soil pathogens, with moderate effectiveness against plat-parasitic nematodes (PPN). In contrast, 1,3-dichloropropene (Telone II or EC) is mostly used against PPNs. Pic-Clor 60 (chloropicrin + 1,3-dichloropropene) is commonly used by growers in the southern states to mitigate most soil-borne pests, including insects, weeds, PPNs, and pathogens. Metam potassium (Vapam) can be used alone or in addition to these fumigants to suppress mostly weeds, PPNs, and pathogens to a lesser extent.

In addition to soil fumigation, growers may use other pest management practices, such as crop rotation, cover cropping, and biological control, to reduce the need for fumigants. However, these practices may not be as effective as fumigation in controlling certain pests and diseases. There is a growing interest in developing non-fumigated production systems, such as anaerobic soil disinfestation, to reduce the environmental impact of fumigation and improve the sustainability of strawberry production.

Growers who abstain from fumigation likely have diverse reasons for their choice, including a lack of labor access or affordability, technical expertise, personal farming philosophies, the necessity to maintain protective zones around fumigated areas, or compliance with other regulations linked to fumigation. For some growers, the economic advantages of soil fumigation may not be apparent.

Mulching

Plastic mulch is usually laid after the preplant interval indicated in the fumigant of choice (if any). Traditional raised beds are 6” to 8” high, 30” to 24” wide, 3-5 ft apart from center to center, and covered with plastic mulch. Many growers in FL, are opting for compact raised beds, usually 24" to 20" wide and 12" high. This facilitates harvest, water, and fertilizer concentration around the roots of the plants. Few growers in NC are following this trend for more compact raised beds. Beds are usually covered with black plastic mulch to increase soil temperature during the winter months. A single drip line is positioned along the bed's surface before the plastic mulch is installed. Some growers may use two irrigation lines, one for each strawberry row.

Transplanting

One of the most time-consuming activities is transplanting, followed by winter protection. Several strawberry transplant types are available and have different labor requirements. Strawberry production systems used in the south U.S. region are typically planted using “green” strawberry transplants (plugs or bare-root seedlings) in early fall in double rows at densities of approximately 15,000 to 17,500 plants/acre on fumigated raised beds. In central and western NC and VA, planting dates are early to mid-September, while coastal areas are planted late-September to early October. In the remaining states, strawberries are usually planted in early to mid-October.

Workers transplant fresh-dug or bare-root plants by hand or using a small tool in annual hill plasticulture systems. Workers must be trained to ensure these plants are set at the appropriate depth. Strawberry plugs can also be planted by hand or mechanically with a water wheel. Workers will return to the field within 1 to 2 weeks to replace unthrifty or dead transplants.

Holes for planting plugs and bare-root plants can be punched by hand using homemade tools or a water-wheel transplanter. Planting holes for plug plants should be conical and about 2 inches deep. Planting holes for bare-root and cut-off plants must be deeper, usually around 4 to 6 inches. Strawberries are planted 12 to 17 inches apart in double rows. Strawberry plugs are the most common transplant used in VA, although some growers might use bare-root transplants if plug availability is low. Plants usually come from the surrounding states (NC, NY, NJ, TN), CA, or Canada. Except for the owner/operator, workers typically re-enter the fields to hand weed or apply winter row covers or overhead irrigation for freeze protection.

Freeze Protection

In cases where the temperature drops below 32F (VA, NC, SC, GA, and a few times in north FL), and the dew point is low enough that ice crystals form, farmers will extend floating mats, also known as row covers, to protect the crop during the night. Floating row covers (between 0.5 and 1.5 ounces) can also be used in the fall to increase the amount of heat units given to a strawberry plant. This is especially important when seedlings are planted too late. Row covers are more effective when placed during the day to absorb sun and heat for a few hours to offer protection during freezing hours at night. Strawberry plants will remain dormant during December, January, and February in all the considered states except for FL. After air and soil temperatures rise in early March, they will emerge from dormancy and produce new roots, leaves, crowns, and influences. Beware of spider mites or aphid outbreaks under covers if left for too long or if the fields have a history of these pests.

Irrigation System Maintenance

In VA and NC, there are little to no practices during the first month of the season, as plants develop their root system before entering dormancy due to the sudden drop in temperature in early to mid-November. Many growers do not drip irrigate their strawberry seedlings during this period. In NC, most growers apply overhead irrigation at a rate of 0.10 inches per hour for 5 hours on the first day, 3 hours on the second day, and up to 2 hours on the third day, depending on weather conditions. Bare roots are primarily used in FL; thus, overhead irrigation begins immediately after the plants are set. The common practice is to water for 7 to 14 days after transplanting (depending on weather conditions). Overhead irrigation usually covers the entire field evenly, including field edges, with a small amount of water. At the end of the establishment period, each plant has two or three vigorously growing, fully green leaves.

Sanitation

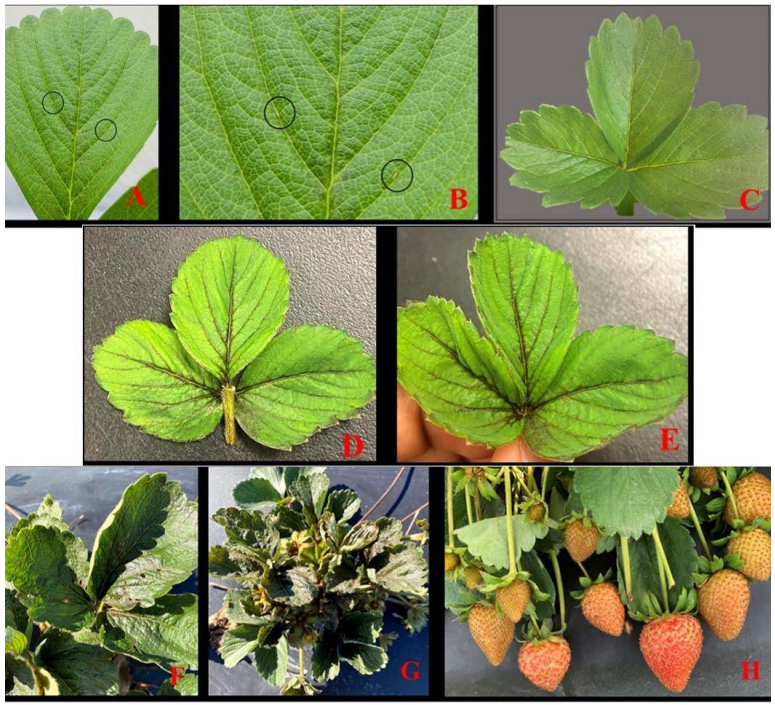
Removing and destroying infested plant material can reduce pest populations. Removing dead or diseased plant material on the plants and alleys can also mitigate disease incidence and pest infestation. Allowing runners to grow free can increase fruit production on multiple-year plantings and exacerbate pest infestations such as cyclamen mite infestations. Workers set transplants and cut runners in early and mid-season. Workers will hand-pull branch crowns through the plastic film during the pre-harvest period. At this time, workers will also hand remove any weeds that have emerged in the area of the transplant hole. Both pre- and post-emergent herbicide applications are applied in winter or

early spring (row middles) with shielded, tractor-mounted spray equipment. More than 25% of the industry uses annual ryegrass in the middle for weed suppression, soil conservation, and later for spring mulch during harvest. Other producers (not using annual ryegrass) keep the row middles weed-free with shielded post-emergent sprays of paraquat in the late post-plant, dormant, and pre-harvest periods. After the pre-harvest herbicide application, a backpack sprayer or weed eater may control escaped weeds in the row middles.

Insect And Mite Management

Monitoring for pests biweekly from planting until the end of the vegetative stage is essential. Once plants start to flower, pest monitoring should be conducted more often (at least once a week) to avoid pest outbreaks. Most pesticides are applied from early spring and into harvest, primarily with drop-nozzle field-type sprayers delivering 150 to 200 pounds per square inch (psi) in 50 to 100 gallons per acre. Some growers may include one insecticide and/or miticide application in the fall or early winter when warm temperatures have been common to address spider mites or aphids proliferating under row covers. Similarly, a few fungicide applications may be used in the fall or winter before forecasted rainy periods. Most growers have strawberry plantings as part of diversified crop operations and rely primarily on insecticide applications for arthropod management. In northeastern states, few growers are familiar with using natural enemies such as predatory mites; however, most growers are interested in opportunities to evaluate their performance on their farms. Few large scale farmers are already assessing the use of predatory mites in their farms, especially under protected structures.

Because FL strawberries do not truly go dormant, insect and mite management needs are constant from planting until crop termination. Pest monitoring is needed weekly, if not more often. Chilli thrips can be established in the crop immediately after transplant and may cause injury as soon as 1-2 weeks after transplant. Many growers hire professional scouts dedicated exclusively to monitoring pests and implementing management tactics. Similarly, various growers have adopted the release of predatory mites and chemical products to control mites and thrips in their plantings. Large acreage farms usually use digital tools to maintain their pest monitoring records. A few large farm managers use precision ag services such as releases of natural enemies using drones and mapping systems.



Chilli thrips feeding on strawberry leaf veins (A and B), initial leaf symptoms of *their* feeding, darkening of leaf veins (C), feeding symptoms (D and E)., severe plant damage (F and G), and strawberry fruit bronzing caused by chilli thrips (H) (Photo by Gagandeep Kaur, Kaur and Lahiri, 2022).

Harvesting

In Virginia and Georgia, strawberries are typically harvested by hand, with a few workers picking the berries directly from the plants, and most of the harvested berries (~80%) are being picked directly by consumers in PYO systems during the early summer. Growers traditionally start their harvest activities in late April through early June (6-7 weeks of harvest), with some farms open to the public 7 days a week and about 1,500 visitors per week.

In North Carolina, South Carolina, and Florida, strawberries are also harvested by hand, but growers may use carts to assist with the process. These machines use conveyor belts

and other equipment to help workers pick the berries more efficiently. In Florida, strawberries are typically harvested using a machine called a "mule train," which consists of a series of carts pulled by a tractor. Workers ride on the carts and pick the berries as they move through the fields. Regardless of the harvesting method, berries are handled carefully to avoid damaging them. After harvesting, the berries are typically sorted and packed for shipment to markets and other buyers. For wholesale markets, growers use refrigerated trucks to transport the berries to their destination, which helps to preserve their quality and freshness. In FL, fruit is harvested by hand every three days throughout the harvest season (November through March). Generally, there is one picker for every acre during non-peak parts of the production season and one-and-a-half workers per acre during the peak parts of the season. Picking is finished in four hours each day during the non-peak parts of the season, while picking takes place eight hours a day during the peak. The shipping container is often what is filled in the field, so very little re-handling occurs.

In northeastern states (except for FL), runners are usually not a problem until later in the season. At this point, most farmers have abandoned their fields or substituted the strawberries for a new crop. Work activity usually is maximum during harvest (after April), when farmers rely on a combination of customers picking their own fruit and external paid labor to help keep the plants clean and allow fresh fruit to be retailed.

PRODUCTION PRACTICES

Strawberries are a high-value crop that requires high initial investments (particularly in protected systems) and long-term investments due to their length of season (8-10 months). Most strawberries produced in the region are grown in an annual hill plasticulture system. The most commonly used cultivars from Virginia to Georgia include Chandler, Ruby June, Sweet Charlie, Albion, and Merced. The major varieties grown in Florida include Florida Brilliance, Medallion, and Sweet Sensation. Transplants are set in late September through early November. Drip and overhead irrigation are used to help establish, irrigate, and protect the plants from frost. Following early vegetative growth, the cool nights and short days of winter stimulate the plant to produce flowers that, after pollination, develop into fruits ready for harvest in four to six weeks in Virginia through Georgia. In Florida, plants bloom as soon as 2-3 weeks after transplant and bear fruit approximately 6-8 weeks after transplant (November-December). A few small growers produce strawberries in matted row systems without plastic mulch or drip irrigation. These systems are generally not harvested in the first year and are maintained for three to five years. Matted row systems may be susceptible to pests such as snails and grubs and root diseases in solid without proper drainage.

Fertilization

Apply fertilizer in the fall according to soil test recommendations. The rule of thumb for VA, NC, SC, and GA is to apply 1/3 to 1/2 of total N in the fall (60 lb/A), all of the phosphate in the fall (120 lb/A), and 1/2 of potash in the fall (120 lb/A). Incorporate thoroughly into the soil used to form beds. For the rest of the season, split the remaining fertilizer into weekly evenly distributed applications through irrigation (fertigation) starting in February. For strawberries in Florida apply 20-25% of the recommended potassium (K) and 30-50 lbs of sulfur (S) per acre preplant. During the season, fertigate with 10.5-14 lbs of nitrogen (N) per acre in weekly applications, adjusting as needed for a seasonal total of around 175 lbs N per acre.

High Tunnel Greenhouse

High tunnels are essential tools for small farmers looking to extend their growing seasons in areas where strawberries undergo true dormancy. They raise temperatures during winter and early spring, advancing June-bearing strawberry production by 4 to 5 weeks.

High-tunnel-grown strawberries in NC.

In North Carolina, growers may extend their season, harvesting as early as December in some areas in the east of the state. One key factor for success in high tunnel production is cultivar selection. Promising cultivars should adapt well to the unique microclimatic conditions under high tunnels, such as high humidity, low light levels, and significant temperature fluctuations between day and night. Additionally, cultivars should have the potential to produce fruit in early and/or late seasons.

High-top benches for strawberry production in NC.

Pest-Free Transplants

Growers who produce their own transplants should raise them under conditions that will minimize the introduction of pests. Sanitation, isolation of transplants from infested areas, a frequent and thorough examination of plants for initial infestations, and prompt treatment will favor plant establishment and minimize pest problems in the greenhouse or other plug production facilities. Growers who purchase plants are also strongly encouraged to inspect them carefully for pests such as mites and thrips, and for diseases, including anthracnose, Phytophthora crown rot, leaf spot, viruses, and Neo-p. Growers are encouraged to be part of the diagnostics and clean plant services provided by the NCPN. The National Clean Plant Network (NCPN) comprises clean plant centers throughout the US that provide clean plant propagation material. The Micropropagation and Repository Unit (MPRU) is the NCPN center in the southeastern region (Raleigh, NC) that provides certified pathogen-tested strawberry material. For more information, see the NCPN website at https://www.nationalcleanplantnetwork.org/berries

Site Selection And Preparation

Appropriate strawberry planting sites are well-drained, with loose soil. Plants should be planted at proper depth when soil temperature and moisture are favorable. Summer cover crops and the utilization of composts are becoming more popular with some growers. Excess plant residue from cover crops clogs bedding equipment, makes poor beds, binds fumigant, reduces fumigation effectiveness, and will result in severe bed slumping the following spring. Fumigants are generally applied during bedding, but row middles are not treated. The bed is then immediately covered with plastic mulch. Florida strawberry industry has partially transitioned from using virtually impermeable film (VIF) to Totally impermeable film (TIF) mulch.

Open-field strawberry production with rye-grass between beds in Duplin County, NC.

Removal/Rouging

Depending on the objective (crop rotation, cover cropping, or second crop in the same plastic), farmers can:

- Eliminate the crop by stopping irrigation and removing the plastic mulch and drip line after plant death.
- Prepare for a second crop by either pruning or burning the strawberries with an herbicide before planting a second crop using the same raised beds and plastic mulch (double cropping). Paraquat is a commonly used herbicide for this purpose.

Properly timed removal and rouging (destruction and burial) of diseased plants or alternate hosts surrounding the field will reduce pest problems.

Organic And Sustainable Production

Organic strawberry production has increased faster than conventional production, driven by premium prices which can be 70-90% higher than conventional strawberries. Although most strawberry acreage is grown using conventional methods, there is increasing interest in organic strawberry production in the region. Growers who choose sustainably or "organic" methods of control (no synthetic chemicals) must consider several factors. Organically produced products are not the same as sustainably produced products. In the United States, the U.S. Department of Agriculture (USDA) National Organic Program governs which practices can be used for crops to be considered certified organic. Organic production practices include no use of synthetic fertilizers, synthetic pesticides, genetically modified organisms, and sewage sludge. The phrase “sustainable practices” includes many practices used by and required of certified organic producers, but the “sustainably produced” designation does not require any verification or certification on the part of the producer.

Strawberry Cultivars

Most strawberries in the region are produced in plasticulture, and the most commonly grown varieties include:

Florida Brilliance:

- Short-day strawberry cultivar (released in 2018)
- Firm, glossy, and conical in shape
- Yield the highest among FL cultivars
- Early yields (late November through January)
- Moderately resistant to anthracnose fruit rot and Phytophtora
- Commonly grown in Florida

Medallion:

- Short-day variety with intense flavor
- Consistent conical shape, glossy, and firm
- Compact and upright plant that allows for easy harvest
- Optimum yield when compared to ‘Florida Brilliance’ and Sweet Sensation
- Produces fewer runners than standard varieties
- Commonly grown in Florida

Chandler:

- Standard variety
- Consistent performance under year-to-year variations in environmental conditions
- Large fruit and high yields
- Skin and flesh – deep red
- Does well in NC, VA, north of Atlanta, mountain area SC

Camarosa:

- Very large and firm fruit, preferred for shipping
- Dark red skin before fully ripe
- Purple when fully ripe
- Performance is not as consistent as ‘Chandler’
- Poor quality in cool weather
- Adapted to warmer areas of the South
- Harvest at proper ripeness
- Very susceptible to anthracnose
- SC and GA

Sweet Charlie:

- Developed for winter production in Florida and Georgia
- A week earlier than ‘Chandler’
- Often planted for early production
- Medium fruit size and red color
- Appears to have some tolerance to anthracnose
- Fruit quality deteriorates quickly in warm weather
- Yields are significantly lower than ‘Chandler’
- Yield compensation: Plant earlier and increase population

Ruby June:

- California cultivar - good adaption for growing in the Southeast
- Short day variety
- Large, firm, and high-quality fruit
- Dark red color with a very good shelf-life
- Medium-high yield comparable to 'Camarosa' but less than 'Chandler'
- Good alternative to 'Chandler' and 'Camarosa'
- High disease tolerance, especially against fusarium wilt

Merced:

- California cultivar

Short day variety
- Large fruit and good firmness
- High yield with excellent heat tolerance
- Bright red fruit color - lighter than 'Camarosa' internally and externally
- Resistant to phytophthora crown rot and common leaf spot
- Moderately resistant to powdery mildew
- Moderately susceptible to anthracnose crown rot

Albion:

- Day-neutral variety
- Large, firm fruit
- Bright red internally and externally
- Resistant to phytophthora crown rot and anthracnose crown rot
- Heat tolerant
- Higher yield if given extra water and nutrients
- SC and GA

Camino Real:

- Short day variety
- Dark red color - comparable to 'Camarosa' internally and externally
- Attractive, mostly symmetrical conic fruit
- Yield comparable to 'Chandler'
- Resistant to phytophthora crown rot
- Moderately resistant to anthracnose crown rot

Also: San Andreas (GA), Fronteras (GA, SC gaining), Flavorfest, Florida Pearl (FL), Sweet Sensation, and Florida Sensation (GA, FL).

Crop Rotation

It is advisable to avoid planting strawberries in the same place year after year. Many strawberry growers use a 3-5 year rotation. Avoid rotating with crops susceptible to root-knot or sting nematodes or crops with high attractiveness to thrips. Growers with established PYO operations find it more challenging to implement rotation plans successfully since accessibility and marketing to consumers may be limited during rotation. Rotation allows for soil-building management practices and a reduction in pest pressure due to life-cycle disruption.

PRODUCTION COUNTIES

Counties highlighted in green on the map represent counties with known and reported strawberry acreage, except for NC, for which only the major producing counties are highlighted in green. FL, GA, SC, and VA counties with the highest strawberry acreage reported for each state are mentioned in the notes below.

Florida: Hillsborough County includes more than 80% of strawberry acreage in the state.

Georgia: Appling, Hall, Harris, and Tift counties are the major producing counties.

North Carolina: Strawberries are produced in all 100 NC counties. The ones with the most strawberry acres are Beaufort, Buncombe, Carteret, Cleveland, Craven, Duplin, Gates, Guilford, Harnett, Johnston, Nash, Randolph, Robeson, Rockingham, Rowan, Surry, Swain, and Union counties (highlighted in the map).

Virginia: The major concentration of strawberry production is in the Chesapeake and Virginia Beach area.

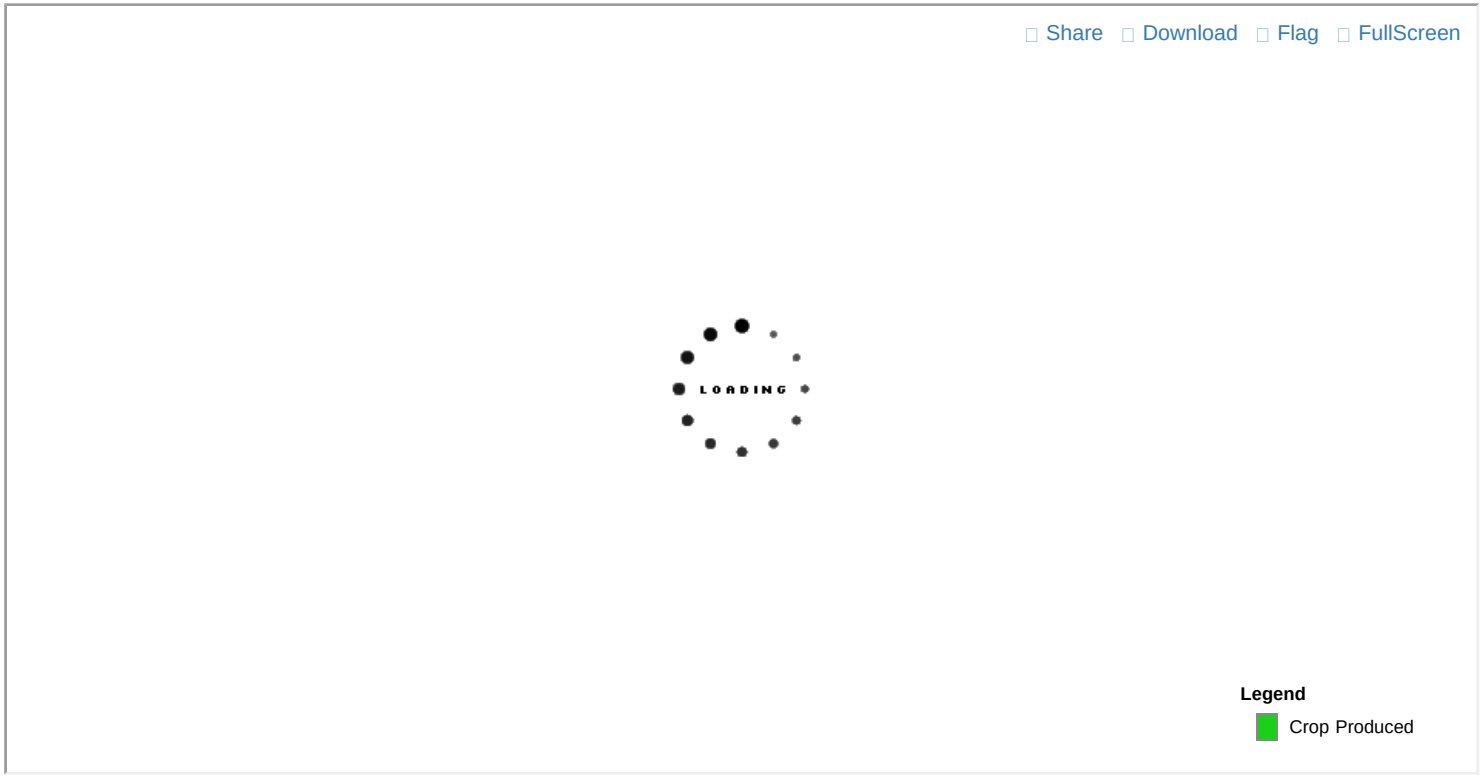
Florida Counties:
Alachua, Hillsborough, Manatee, Marion, Palm Beach, Pasco, Polk

Georgia Counties:
Appling, Hall, Harris, Tift

North Carolina Counties:
Beaufort, Buncombe, Carteret, Cleveland, Craven, Duplin, Gates, Guilford, Harnett, Johnston, Nash, Randolph, Robeson, Rockingham, Rowan, Surry, Swain, Union

South Carolina Counties:
Abbeville, Aiken, Anderson, Cherokee, Chester, Colleton, Darlington, Dillon, Dorchester, Edgefield, Fairfield, Greenville, Greenwood, Jasper, Laurens, Lee, Marlboro, McCormick, Oconee, Union, Williamsburg, York

Virginia Counties:
Charlottesville, Chesapeake, Northampton, Richmond, Virginia Beach



PRODUCTION FACTS

In 2022, strawberries were the third most sold fruit in the United States, with an annual utilized production of 13.9 million tons. Strawberries are grown in all states, but most of the crop is produced in California and Florida, followed by New York, North Carolina, Oregon, and Washington. In 2022, strawberry production increased by 20% compared with 2021, and an additional 6% increase was observed in 2023 (787 additional acres growing strawberries).

Table 1. Number of acres bearing strawberries, operations with area grown, and average operation size (acres/operations) in VA, NC, SA, GA, and FL (USDA- NASS, 2022).

State	Acres Bearing	Operations	Average Operation size
Virginia	205	231	0.88 acres
North Carolina	1,012	340	4.32 acres
South Carolina	707	192	3.68 acres
Georgia	249	150	1.66 acres
Florida	13,413	280	47.9 acres

Total in aggregate	15,586	1,193	2.63 acres (without FL)

Production Year	2022
US Rank	#2 (FL) and #3 (NC) producing states
% US Acres	27.63
Acres Planted	56,400
Acres Harvested	56,300
Growers	8,491
Production	1,426
Production Costs/Acre	$6,222 (2020 estimated costs FL)
Natl Avg/Acre	
State Avg/Acre	
Per Acre Value	
Production Value	$3,259,100
Price	$128 per cwt (2021)
Crop Budget URL	https://edis.ifas.ufl.edu/publication/FE1013
References	Guan, Z., Wu, F., & Whidden, A. (2024). *Florida strawberry production costs and trends* (FE1013). University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024 U.S. Department of Agriculture, National Agricultural Statistics Service. (2022). Noncitrus Fruits and Nuts 2021 Summary. USDA Economics, Statistics and Market Information System. Retrieved October 30, 2024, from Wade, T., Amon, K., Guan, Z., & Elwakil, W. (2024). *A review of strawberry production and price trends from 2010 to 2022* (FE1143). University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024 U.S. Department of Agriculture, National Agricultural Statistics Service. (2022). *Quick Stats database.* Retrieved October 30, 2024

IPM PRACTICES

In the context of strawberry production in the southeastern US, IPM practices are essential due to the region's warm climate, which can be conducive to multiple pest complexes. Below is a general overview of IPM practices that are often considered in strawberry production in the region:

Site selection: Choosing fields away from wooded areas can significantly reduce the risk of infestation from pests like the strawberry bud weevil.

Resistant cultivars: Cultivar selection plays a crucial role in IPM to reduce pest damage. Some cultivars are resistant to specific pests and diseases. See the Production Practices section for more information regarding varieties.

Crop rotation: Rotating strawberry fields regularly (every 3-5 years) with other crops can help break disease and pest cycles.

Water and dust management: Proper irrigation can reduce the risk of certain pests and diseases. Twospotted spider mites prefer to be established in dry and warm areas with water-stressed plants. Similarly, dust falling in plants can exacerbate twospotted spider mite infestations.

Monitoring and decision-making: Regular scouting of fields for signs of pests can help detect problems early. Maintaining detailed records of pest populations, disease incidence, treatments, rates, date and time of application, and their outcomes can help make informed decisions in the future.

Action thresholds: When available, following thresholds (the pest population level at which it's economically justified to take control measures) ensures that treatments such as pesticide applications are economically justified and timed correctly.

Chemical control: Pesticides should be integrated together with other IPM tactics but chosen carefully to minimize harm to beneficial insects, such as pollinators and natural enemies. Rotating pesticides with different modes of action is crucial to prevent resistance. When properly implemented, biological control, such as the release of predatory mites and chemical control, has demonstrated good potential in strawberry thrips and mite management.

While the above practices are general for the region from Virginia to Florida, it's important to note that some specific pests and challenges can vary by state and even by local microclimates. In addition to the general practices, growers in these states must also be aware of state-specific regulations, pesticide registrations, and recommendations. For more detailed IPM practices, see the Southern Region IPM Guide for Strawberries.

POLLINATOR PROTECTION

Before making any pesticide applications, monitor arthropod (insect and/or mite) populations to determine if treatment is needed. If pesticide (fungicide, insecticide, or miticide/acaricide) application is necessary:

1. Prioritize selective pesticides over broad-spectrum chemicals to reduce the risk to pollinators and other non-target beneficial insects. Both acute and chronic pesticide exposure can negatively affect beneficial insects (pollinators, insect parasitoids, and predatory arthropods).

2. Read and follow ALL pesticide label directions and precautions. **The label is the Law!** EPA now requires the addition of a “Protection of Pollinators” advisory box on many pesticide labels. Look for the bee hazard icon in the "Directions for Use" section and within crop-specific sections for instructions on how to protect bees and other insect pollinators.

3. Avoid applications when bees are actively foraging in the crops to minimize infield exposure of bees to pesticides. Bee flower visitation rate is highest in the early morning. Apply pesticides in the late afternoon or early evening to allow maximum residue degradation before bees return the next morning. Bee foraging activity also depends upon the time of year (temperature) and stage of crop growth. The most significant risk of bee exposure is during bloom; both honey bees and wild bees provide pollination services to blooms that improve fruit yield.

4. Follow label directions to minimize off-target movement of pesticide applications. Do not apply pesticides when the wind is blowing towards beehives or off-site pollinator habitats, which provide important resources for bees.

PESTS

Insects

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Aphids (strawberry aphids, potato aphids, green peach aphids)	Low	Many different aphid species feed on southeastern strawberries, including the strawberry aphid (*Chaetosiphon fragaefolii*), potato aphid (*Macrosiphium euphorbae*), and green peach aphid (*Myzuz persicae*). Recent monitoring efforts have also found *Chaetosiphon minor* and the yellow rose aphid (*Rhodobium porosum*) to occur on strawberries. Most species alternate between generations of parthenogenic ("self-cloning")	At very high densities on young plant tissue, causes water stress, wilting, plant stunting, and sooty mold growth. Vector of many plant viruses that are problematic in second-year fields.	acetamiprid azadirachtin bifenthrin flonicamid imidacloprid thiamethoxam bifenthrin (G) thiamethoxam (G)(Flowering) flonicamid (G) flupyradifurone (G) imidacloprid (E) Severe infestations are rare but populations can grow quickly under row coves. Threshold for chemical application is usually when 30% of plant samples are infested. Beware of aphid outbreaks caused by pyrethroid applications, these are not IPM compatible and can kill natural enemies.	Aphids are frequently kept under control by numerous predatory insects including: parasitoid wasps, syrphid fly larvae, lacewing larvae, and lady beetles and their larvae. These predators occur naturally around strawberry fields. Aphidius, protective structures	Banker plants	

		females that give birth to live young and generations of winged males and females that reproduce sexually. Immature aphids, called nymphs, can go from birth to adulthood in less than two weeks, so populations have the potential to increase rapidly. Many natural enemies eat aphids, so damaging infestations are rarely an issue in North Carolina and Virginia strawberries.					
Brown marmorated stink bug (*Halyomorpha halys*)	Emerging	Stink bugs rarely cause significant damage to the fruits but can create contamination issues when adults or immatures are present in the crates, or their eggs are laid on the harvested fruits.		bifenthrin (P) spirotetramat		Sanitation	
Chilli thrips (*Scirtothrips dorsalis*)	High	As of 2024, establishment only confirmed in FL and NY, with multiple detection reports in the remaining states in the region. Lower activity in December but come back in mid-January. An invasive species of thrips measuring between 1-2mm in size, and high capacity for reproduction make them hard to	Prefers to feed on younger, nutritious, softer tissues of host plants, such as on meristems or terminals. They do not feed on mature plant parts. *Scirtothrips dorsalis* use their stylet-like mouth parts to penetrate into the young leaves. The wounds they make in the leaves in the process of feeding lead to	acetamiprid cyantraniliprole novaluron spinetoram (amixture of spinetoram-j and spinetoram-l) tolfenpyrad **Conventional:** spinetoram (amixture of spinetoram-J and spinetoram-L) acetamiprid novaluron Exirel and Apta (80% mortality).	• *Neoseiulus cucumeris* • *Stratiolaelaps scimitus* • *Amblyseius cucumeris* • *Amblyseius swirskii* • *Orius spp.* • *cucaburous* • *embursucous* Releasing predatory mites, unsure on efficiencies.		Removal of hosts and weeds around main crops that can support thrips populations.

		manage.	necrosis and the development of brown to black color. Severe infestation can result in complete host plant damage and crop loss. Infest plants early in the season. Heavy feeding causes reddening and darkening of leaf veins and petioles. With severe infestations, the entire leaf turns dark, crinkled, and deformed. Feeds on leaves, flowers, and fruits, causing leaf distortion, bronzing, and cracking of fruits, which ultimately results in reduced crop yields.	**Organic:** spinosad flupyradifurone pyrethrins Organic strawberries use Azera (neem +pyrethrins) works somewhat on chili thrips in FL. Spraying based on pest monitoring. It is resistant to the pyrethroid group (FL). It is using Radiant and Assail (poor, then thrips come back even worse).			
Common blossom thrips (*Frankliniella schultzei*)	Low	*Frankliniella schultzei* manifest two different color morphs, a dark and a pale form. Both the brown and yellow morphs exist in Florida, although the dark morph is more common. Adult females are 1.1-1.5 mm long, whereas adult males are 1.0-1.6 mm long. Body color, body setae, and a comb on the 8th abdominal segment usually identify thrips species.	Both adults and nymphs feed on pollen and floral tissue, leading to flower abortion. Severe infestations can cause discoloration and stunted growth of the plant.	bifenthrin cyantraniliprole flupyradifurone imidacloprid + lambda-cyhalothrin spinetoram (amixture of spinetoram-j and spinetoram-l) flonicamid Same as those for Florida flower thrips.	Same as those for Florida flower thrips.		Same as those for Florida flower thrips.

		At a temperature of 75°F, it takes around 12.6 days for a complete generation of thrips to finish their life cycle.					
Florida flower thrips (*Frankliniella bispinosa*)	Low	Florida flower thrips are believed to be native to Florida and is the most common species in many Florida crops, including strawberries. The body is elongated, approximately 1 mm (0.039 in) in length, typically with the female slightly larger. Body and legs are yellow, with brown setae (hairs). Antennae are eight-segmented with stout, brown spines on the second segment. Female thrips possess a saw-like ovipositor used to insert eggs into the foliage of a host plant. Larval and adult thrips are typically found feeding in concealed spaces of the plant, and the prepupal and pupal stages are found in the soil. At 77°F it takes 10 to 16 days for these flower thrips to develop from an egg to adult. As the temperature gets cooler the amount of time it takes to reach	Thrips cause flower and fruit abortion, petal browning, necrotic flecking, and distorted, bronzed fruit. Feeding on the flowers can cause withering of anthers and stigmas, resulting in non-uniform fertilization, which produces malformed fruit. Feeding on the fruit may result in cracking, bronzing, and a reduction in fresh weight. Bronzing can also be caused by factors other than thrips, including cyclamen mites and spray applications.	acetamiprid cyantraniliprole flupyradifurone imidacloprid + lambda-cyhalothrin spinetoram (amixture of spinetoram-j and spinetoram-l) tolfenpyrad thiamethoxam Thrips can often be difficult to control effectively with insecticides because their cryptic behavior limits their exposure to contact insecticides. Pests on strawberry blossoms can be scouted by tapping flower clusters above a paper cup or plastic bag and counting the number of thrips. The recommended control threshold for thrips on strawberries is 15 of the 30 blossom clusters are occupied with thrips (University of Delaware). When using chemical control, it is necessary to rotate insecticide groups to prevent a buildup of resistance in thrips populations. Flower thrips may be protected from systemic insecticides as there may be a lack of uptake into floral tissues. Thrips populations also display a great ability to build up resistance to insecticides. Beware that broad-spectrum insecticides may favor the buildup of other thrips such as western flower thrips,	Insecticide application decisions for thrips management in strawberry should consider the presence of naturally occurring natural enemies and the species of thrips present. Naturally occurring predators include: • *Neoseiulus cucumeris* • *Stratiolaelaps scimitus* • *Amblyseius swirskii* • *Orius spp.* The beneficial predator *Orius spp.* (minute pirate bug) is commonly found in *Bidens* spp. (Spanish needle).		Removal of hosts and weeds around main crops that can support Thrips populations. Weeds that may be found around Florida strawberry fields that are hosts to thrips are *Bidens spp.* (Spanish needle) and *Raphanus raphanistrum* (wild radish). The majority of the thrips in these weeds in Florida are *Frankliniella bispinosa*. Plastic mulches that reflect UV are used as repellents to prevent colonization of field-grown fruiting vegetable and fruit crops. Reducing the amount of nitrogen applied to the crop may help mitigate thrips infestations.

		adulthood increases.		which is more tolerant compared with their predators and competitor native flower thrips, leading to more severe infestations. Limiting insecticides to those compatible with natural enemies and preserving populations of less damaging native competitor thrips are recommended.			
Pepper thrips (*thrips parvispinus*)	Emerging	These invasive pest have been found in strawberries in Florida, but the extent of their damage or establishment in this crop is still unknown. Small pest, measuring 1 mm long, making them difficult to spot without magnifying lenses or trained eyes. Adult females are typically dark brown, ranging from brown to black, with light-colored legs and head. Their wings are lighter near the base. In contrast, males are entirely yellow and are about 0.6 mm long. The larval stages closely resemble the adult without wings. The life cycle consists of an egg, two nymphal stages, prepupa, pupa, and adult, completing its life cycle in the span of 13–14 days. Males have a brief lifespan of around six days, while females live for approximately nine days. Females	Adults and larvae feed on leaves and flowers, potentially causing significant damage to plants. Early identification of the damage is important for effective pest management strategies. Common signs and symptoms of infestation include silver scars on foliage, especially in fully developed leaves, distorted or deformed growth, premature leaf drop, scarring on fruits, and the presence of adults and/or larvae. Proper identification is essential, as its damage can resemble damage caused by other pests, such as broad mites.				

		can reproduce without mating and can lay approximately 15 eggs during their lifetime. The list of their hosts in the U.S. is still under assessment, but their known host species list includes ornamentals, vegetables, and fruit crops, such as citrus, strawberry, eggplant, peppers, cucumber, beans, zucchini, and more.					
Sap beetles, species complex	High in Some Locations	Sap beetles are tiny beetles (1 /4-1 /8" long) in the family Nitidulidae. Most species overwinter as adults, frequently in wooded areas, and migrate into strawberry fields around the time fruit are ripening. Adult sap beetles are attracted to the odor of rotting fruit, and females lay eggs in debris near rotting fruit. Larvae feed inside the fruit then pupate in the soil nearby their food source. Sap beetle larvae have light brown head capsules, three distinct pair of legs, bristles along their bodies and two projections on the end of their abdomen. After pupation, the adults may also feed upon strawberry fruit.	Feeding damage primarily occurs in rotting, damaged, or overripe fruit, but will occasionally be seen in sound fruit when populations within fields are large. In addition to damaging the fruit directly, beetles introduce fungi to the fruit that cause it to ferment. Growers can monitor sap beetles by checking fruit directly and can use buckets containing rotten fruit or whole wheat bread dough placed in the ground along the edges of fields to trap adults. Traps should be checked and baits replaced at least weekly, and	fenpropathrin novaluron bifenthrin (G) at least 2 applications Cultural methods may not sufficient to control sap beetles, particularly if rain delays harvest. In these cases, foliar insecticides may be used. Rimon (novaluron) is recommended for use against sap beetles, but bifenthrin and fenpropathrin may also be used. Novaluron is an insect growth regulator and is most effective against sap beetle larvae. Bifenthrin and fenpropathrin are more effective against adult beetles and do not necessarily reduce larval damage.		Sanitation	Removal of rotten or overripe fruit from the field is the most important control method for reducing sap beetle populations and is often sufficient to prevent damage.

		In Florida, conditions can support two generations of sap beetles per year.	old bait should be disposed of away from fields.				
Seed bugs	Low						
Spotted-wing drosophila (swd) (*Drosophila suzukii*)	High	*Drosophila suzukii* is an invasive pest of soft-skinned fruit crops, including strawberries, raspberries, and blackberries. SWD is now established in all fruit-growing regions of North Carolina and infests blueberries and grapes, as well as peaches, and wild berries. Male SWD have a single spot on their end of each wing and two paired black combs on each foreleg, which distinguishes them from native *Drosophila* spp. Female SWD do not have spots on their wings or combs on their legs but possess a larger, more heavily sclerotized ovipositor than native *Drosophila* spp. which allows them to pierce the surface of undamaged berries to lay eggs. In contrast, other *Drosophila* spp. lay their eggs in already damaged or rotting fruit. Female SWD prefers to lay eggs in ripening and ripe	SWD populations are smaller during the spring fruiting strawberry season, and direct market growers in North Carolina may not need to manage them. SWD populations are highest in the fall, and fall fruiting or day neutral cultivars are at significant risk of damage and usually require treatment.	bifenthrin imidacloprid malathion (no inert use) spinetoram (amixture of spinetoram-j and spinetoram-l) spinosad Chemical control is not generally used in spring fruiting, direct market strawberry production in North Carolina. Day neutral, fall fruiting plantings require regular preventative applications of insecticides effective against SWD starting when fruit ripens to prevent economic loss. Insecticide applications are usually made weekly. Materials effective against SWD registered in strawberries include malathion, bifenthrin, and spinosad. These materials are highly toxic to bees and other pollinators and should be applied in the evening to limit pollinator exposure.	Native natural enemies are not sufficient to maintain SWD below damaging levels. Thanks to international collaborations in classical biological control projects, releases of the host-specific parasitoid *Ganaspis brasiliensis* have been conducted in the U.S. Additionally, another SWD parasitoid, *Leptopilinajaponica*, has established itself in the U.S. in multiple states.	Sanitation	Fruit should be harvested as soon after it is ripe and as entirely as feasible. The longer a ripe fruit is present in the field, the greater the opportunity for it to become infested. Post-harvest, fruit should be stored at cool temperatures, ideally 35 °F or cooler. This will slow egg and larval development and also kill some immature SWD.

		fruit, and larvae develop internally within fruit. Larvae in harvested fruit contaminate the product, and there is zero tolerance for SWD infestation in wholesale marketed fruit. Egg-laying punctures can also introduce pathogens or make it easier for other pests, such as sap beetles and other Drosophila spp., to damage fruit.					
Strawberry bud weevil, strawberry weevil, clipper beetle (*Anthonomus signatus*)	Medium in Some Locations	Strawberry weevil adults are about 1/10 to 1/8 inch-long, including the elongated head and slender snout. Antennae are mounted on either side of the snout with mouthparts at the end. Adult weevils feed primarily on the pollen of flowers, including strawberry, blackberry, raspberry, redbud, dewberry, blueberry, grape, rose and cinquefoil.	Infestations tend to be most prevalent in strawberry fields adjacent to woods, fence rows or similar weedy areas, which may harbor hibernating strawberry weevils. Occurrence tends to be sporadic and uncommon, varying greatly with year and location. Overwintered adults may emerge to feed on various flowers and leaves as early as late March when the temperatures reach the low 60's °F. After moving to strawberry or some other host plants, the female chews small holes in the flower buds, inserts an oval,	bifenthrin carbaryl fenpropathrin spinosad Strawberry cultivars in North Carolina and Virginia annual plasticulture systems do not experience a yield reduction when 18 buds per plant or fewer are removed. While this damage has been observed on commercial farms, it is uncommon, and treatment is rarely needed. If chemical control is necessary, early morning pesticide applications may be more effective as the weevils feed during the day. Spraying the borders of the field or hot spots within the fields may be sufficient for control. A second application may be necessary 7 to 10 days later if the field has a history of weevil problems. Insecticides effective against strawberry bud weevil (bifenthrin, fenpropathrin, carbaryl, and spinosad) are highly toxic to bees, which may be present in fields at the same time, so they should be used with extreme caution should be employed			Strawberry fields away from woods and wild blackberry and raspberry are at lower risk of damage. Annual plasticulture systems which are fumigated are unlikely to carry over weevils from previous years. Matted row plantings should be maintained clean and weed-free, and avoid excessive use of mulch. There is considerable variability in number of strawberry weevils from year to year. Scouting recommendations are as follows: Scouting should begin in late March to April, when temperatures are above 60 °F and flower trusses are visible in the

			glassy egg into the holes, and then girdles the bud stalk below the bud to prevent it from opening and exposing the larva. The damaged bud fails to develop, may turn brown or black, and often falls from the plant. The egg-laying period may vary with winter weather conditions but lasts about a month. Inside the injured bud, the eggs typically hatch in one week, and larvae take approximately two weeks to develop. Strawberry cultivars grown in North Carolina have been demonstrated to compensate for significant bud loss, so strawberry bud weevil is usually not considered an economically significant pest.	to protect pollinators. Chlorpyrifos (Lorsban) is no longer available, and it is no longer recommended against strawberry bud weevil.			crown. Scout along field edges, especially those located nearest potential wintering sites. Weevil infestations emerge rapidly, so sampling should occur at least 3 times a week to avoid underestimating populations. Developing buds should be inspected carefully for either damage or the presence of adult weevils. Adult weevils can be counted, but it is usually easier to sample for clipped buds. Sample once a week in a V-shaped sampling pattern at about 5 to 10 sampling locations. Scout a 2-foot-square section of the row at each sampling location.
Tarnished plant bugs (lygus bugs) (*Lygus lineolaris*)	Medium	Adults are oval, 4-6 mm (1/6- ¼ in.) long, green to brown with triangular markings in the middle of the back. Fly quickly when disturbed. Nymphs are small, 1 to 5 mm (1/25-1/5 in.) long. They are green and	Nymphs feed on flowers and cause varying degrees of fruit distortion. The insects puncture seeds on the developing fruit, causing that portion of the berry not to develop. Sometimes there is a concentration	bifenthrin novaluron potassium salts of fatty acids Use of insecticides can affect natural predator populations and can also disrupt spider mite control. Insecticides are more effective against nymphs than adults. Rimon (novaluron) or bifenthrin are the most commonly used insecticides	Several parasitoids are known, but the egg parasite *Anaphis iole* Girault, and the nymphal parasites *Leiophron uniformis* (Gahan), *Peristenus pallipes* (Curtis) and *eristenus pseudopallipes* (Loan) (all Hymenoptera) are thought to be relatively important. The native parasites seem more effective at parasitizing Lygus on weeds than crops. The imported parasitoid *Peristenus digoneutis* Loan (Hymenoptera: Braconidae) is reported to have decreased tarnished plant bug	Variety dependent. Attracted to weeds including butterweed, fleabane, goldenrod, vetch, dock, and dog fennel. The removal of weed hosts from edges and destruction of overwintering sites will help to reduce damage. Populations may increase rapidly in	Control of weeds, destruction of crop residue, and planting strawberry crops as far away as possible from forage and cotton crops preferred by this pest can minimize population sizes. Mowing or disking

			darken as they mature. The third instar stage has five black dorsal spots and is starting to develop wing pads. Damage is limited in North Carolina, but in states farther south and in the west, economic injury occurs annually. Early maturing cultivars tend to suffer less damage than late maturing cultivars. Day neutral or fall fruiting strawberry cultivars are at highest risk of tarnish plant bug injury in North Carolina. In North Carolina, adult lygus bugs hibernate in plant debris and resume activity in spring. Females insert eggs into succulent host plant tissue with their sword-like ovipositor. Tiny, elongate, slightly curved eggs hatch 1-1/2 to 3 weeks later into the wingless nymphs that range from 1.5 mm to slightly less than adult size, and are yellow-green to green with several black spots on their backs. Immatures are similar in appearance to aphids in that they are small and pale green, yet the body is more	of seeds near the tip, a deformation referred to as button berries, nubbins, or cat-faced berries. When larger seeds are damaged, they often turn brown in color and look hollow. Care should be taken to distinguish Lygus bug damage from misshapen fruit due to poor pollination. Poor pollination is common during the first several weeks of strawberry harvest in NC, particularly following cool, rainy springs. Poor pollination can result in misshapen fruit with seeds that vary in size. Lygus bug injury usually occurs later in the growing season and results in misshapen fruit with seeds of uniform size. Shiny circular spots of excrement on various plant parts also indicate Lygus bug presence, which may pierce buds and terminal growth with their needle-like mouthparts and extract plant juices. New growth may be yellowed and	against tarnished plant bug in instances where treatment is necessary. novaluron (G) birfenthrin (F)(Good 3X, SC and Alabama) If tarnished plant bugs are present, the treatment thresholds are generally very low (University of Minnesota): 3 nymphs on 15 clusters 4 nymphs on 20-30 clusters 5 nymphs on 40 clusters 6 nymphs on 50 clusters	significantly in New Jersey.	strawberry fields if nearby vegetation is mowed. Keep nearby weeds under control and avoid mowing nearby vegetation during bloom and harvest.	weeds during the strawberry bloom period should be avoided since this may force the tarnished plant bug to migrate into the strawberry field. **Scouting** protocols are as follows: Begin monitoring for tarnished plant bugs when flower trusses are first visible. Traps may be set around the edges of the field to monitor adult tarnished plant bugs, but the nymphs do not fly and therefore will not be trapped. To detect nymphs, conduct a weekly sample of at least thirty flower clusters evenly distributed throughout the field (follow a V-shaped pattern) by shaking them over a white surface such as cardboard or plastic. If more than five bugs are found per trap, or the nymph count is greater than 0.25 nymphs per flower cluster before 10% bloom, or there are more than four out of thirty clusters infested with nymphs, then chemical treatment may be justified. If no nymphs are found until mid to late

		tapered, and they move more quickly. The nymphs develop through five instars over a three-week period as they feed on plant sap. The fourth instar nymphs have wing pads, and when mature, molt and emerge as adults. The first few generations develop on preferred hosts such as small grains, alfalfa, wild grasses, vetch, dock, and fleabane. As hay is cut or as other plants dry out, tarnished plant bugs migrate in large numbers to succulent hosts such as cotton or vegetable crops. During summer, the life cycle (from egg hatch to adult emergence) is completed in 4 weeks, with as many as five generations possible each year.	distorted, causing plants to appear unthrifty. Damage from feeding causes a condition known as “button-berry” where the berry tip fails to expand, and seeds are concentrated. Damage is worse on mid to late-season June-bearers, as a second generation emerges as these berries are forming, and also on day-neutral varieties in summer and fall. Leaves from damaged buds are sometimes ragged and discolored. Flowers from damaged buds sometimes fail to develop on one side, or the whole bud aborts.				bloom, the threshold should be raised to 0.5 nymphs per flower cluster.
Western flower thrips (wft) (*Frankliniella occidentalis*)	High	Adults have fully developed wings with long fringes of hairs typical of most thrips. The adult of WTF is less than 2 mm in length. It has three color morphs: dark-brown, light, and intermediate (yellow with a dark longitudinal band along the back). The intermediate morph is the most	Flower thrips' tiny mouthparts pierce and suck plant juices from the outer layer of plant tissue. This feeding does not seriously damage strawberry leaves, but thrips feeding can cause misshapen blossoms and bronzing of the fruit near the leaf cap. Although thrips-	acetamiprid cyantraniliprole flupyradifurone imidacloprid + lambda-cyhalothrin spinetoram (amixture of spinetoram-j and spinetoram-l) spinosad spinosad (G) spinetoram (G) acetamiprid (G) WFT can be difficult to control due to its tendency to develop resistance to	• *Neoseiulus cucumeris* • *Stratiolaelaps scimitus* • *Amblyseius swirskii* • *Orius spp.* *Orius* spp. is the most important predator of this species. Other biological control guidelines are the same as those for Florida flower thrips.		Same as those for Florida flower thrips.

		common in Florida. Males usually comprise a much smaller proportion of the population and are smaller and paler than females. Adults and larvae may be found in similar locations.	vectored viruses and non-viral diseases are common in other cropping systems, transmission has not yet been reported in strawberry.	insecticides. Its prevalence may increase when broad-spectrum insecticides such as pyrethroids are used. Difficulties managing western flower thrips may be due to insecticide resistance, reduced number of predators like *Orius* sp., or the removal of *F. bispinosa* as a competitor. Treatment thresholds for North Carolina have not been established, but work in California indicates the insecticide treatment should be considered only after populations exceed 10 thrips per blossom. Other chemical recommendations are the same as those for Florida flower thrips.			

Pathogens

Plant pathogens attack virtually all strawberry plant parts, resulting in direct yield loss and loss due to quality factors. Infection of fruit by one pathogen may lead to infection or colonization by other pathogens, confounding the situation. Major regional disease problems include diseases caused by Botrytis (gray mold), Neopestalotiopsis (Neo-p), and Anthracnose.

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Angular leaf spot of strawberry (*Xanthomonas fragariae*)	Medium to High	Angular Leaf Spot disease of strawberry, caused by the gram-negative bacterium *Xanthomonas fragariae*, is often confused with common leaf spot and leaf scorch diseases. Once infection is established, little can be done until the wet, cool conditions subside. Fortunately, this disease generally does not affect yields severely.	The pathogen causes water-soaked lesions that first appear on the lower surface of the leaf, becoming angular as they enlarge and are usually delineated by veins. These lesions are first diagnosed by holding leaves toward the sun and viewing from the backside. When conditions are very moist, lesions may exude a viscous yellow substance that is actually a mass of bacteria. Upon drying, a characteristic white film is left on the leaf surface. In time, lesions will also be visible on the upper leaf surface as irregular, reddish-brown spots that a yellow halo may surround.	acibenzolar-S-methyl copper Early application of registered copper materials prior to rapid growth may reduce disease, but fungicides are not very effective in managing angular leaf spot because the bacteria can reside out of reach within the plant tissue. Some growers (3% of entire acreage) will implement a copper-based spray program when disease occurs, applying up to 3 applications of copper using 1.2 to 1.8 pounds	None effective	Clean plants from nursery.	Using rye grass/wind control to prevent damage to plant which then makes it more susceptible to leaf spot. Use of disease-free plants is the most effective way to manage angular leaf spot. However, infected transplants may not exhibit signs of infection until exposed to a more favorable

			Berry caps may become infected, darkened, and unappealing. Vascular infection and wilting by *X. fragariae* may lead to plant death, but this is not as common as leaf spot. *X. fragariae* primarily enters the field via infected planting stock, and may persist in the field by overwintering/oversummering in infected plants and dead leaves. In the Southeast, problems have not persisted from one year to the next in annual plantings due to soil inoculum. Bacteria are splash dispersed to healthy leaves in wet weather or with irrigation water. X. fragariae favors low day (60 °F) and night temperatures (near freezing) and high relative humidity. Favorable conditions for disease development occur during transplant establishment and when frost protecting.	of active ingredient per acre.			climate, such as exists in the southern states. Resistance to angular leaf spot exists in some genotypes, yet no commercially desirable cultivars contain high levels of resistance.
Anthracnose crown rot, species complex (*Colletotrichum gloeosporioides*)	Low	Anthracnose Crown Rot (ACR) is caused primarily by *C. gloeosporioides* species complex and occasionally by *C. fragariae.* Disease control is difficult when environmental conditions are favorable, and the disease can be especially destructive to California strawberry cultivars when grown on black plastic. The pathogen tends to be associated with the crown rot phase of anthracnose but can also affect other plant parts. *C. fragariae* causes crown rot and is not commonly a problem on fruit. It has not been isolated as a common pathogen in North Carolina since 1986.	The most diagnostic symptom of ACR is red and white marbling of the crown. However, initial symptoms of ACR include plant stunting and flagging of young leaves due to lack of water. Initially plants wilt in the heat of the day, which is often over-looked as drought or heat stress. In advanced infection, the entire plant will die. Cutting the crown lengthwise reveals white and reddish brown streaks, creating a marbled effect, or a firm rot. In some cases, ACR can cause leaf symptoms that appear as circular black spots on the upper surface of young to middle-aged leaves. The pathogen can also be transmitted with tips and cause widespread damage in plug production facilities. Plugs will first appear stunted, show signs	captan cyprodinil + fludioxonil fludioxonil + pydiflumetofen fluxapyroxad + pyraclostrobin thiophanate-methyl trifloxystrobin boscalid + pyraclostrobin captan azoxystrobin + propiconazole cyprodinil + fludioxonil pyraclostrobin + fluxapyroxad The effectiveness of fungicides is generally low. Plant dips in cyprodinil + fludioxonil can reduce plant death by up to 1/3 or more. Plants should be field set		Sanitation practices, clean transplants	The use of disease-free plants is the most important management strategy for controlling this disease but nurseries are usually not aware that a problem exists. Although there are rapid detection methods to detect the pathogen, there is no accepted sampling protocol to assure a given plant source is disease free. Resistant plants are not available.

				of wilt starting with the youngest leaf and completely collapse. The small crowns often become marbled or completely brown and infected tips have poor to no root system resulting in widespread collapse when misting frequency decreases. Infected strawberry transplants are the primary source of inoculum in fruiting fields. The pathogen may be present on active lesions but in most cases it is in a quiescent phase – i.e. it has infected green tissue but is not causing symptoms. This symptom-less phase of the disease cycle allows the pathogen to build up undetected and then disease expression occurs under favorable climate conditions (e.g. wet and hot) or when there are some type of chemical/physiological changes in the plant. In nurseries (more in the piedmont and eastern production regions; less in the mountains) and sometimes in fruiting fields, the pathogen can originate from non-cultivated plant species, start off in the quiescent phase but rapidly move to the necrotic or symptomatic phase. In North Carolina, important plants include Virginia creeper (*Parthenocissus quinquefolia*), wild and muscadine grape (Vitis /*Muscadinia rotundifolia*) and smilax (*Smilax rotundifolia*). Additional potential non-cultivated hosts identified in Florida include Air potato (*Dioscorea bulbifera*), Magnolia (*Magnolia virginiana* L.), Wax myrtle (*Myrica cerifera* L.), oak (Quercus spp.), Brazilian pusley (*Richardia brasiliensi*), and Caesar weed (*Urena lobata*).	after treatment as soon as possible to avoid plant stunting problems.			Periodic field scouting, especially during warm and wet weather, enables early detection of anthracnose. As soon as disease is discovered, immediate removal and destruction of infected and surrounding plants has worked to reduce inoculum levels. Avoidance of overhead irrigation as done in the plasticulture system limits conidial dispersal and spread of the pathogen.

			However, this pathogen species is complex and only about 10 to 67% of the *C. gloeosporioides* isolates from these non-cultivated plants are pathogenic on strawberry				
Anthracnose fruit rot (*Colletotrichum nymphaeae*)	High	Anthracnose is an important disease of strawberries, with all parts of the plant (fruit, crowns, leaves, petioles, and runners) being susceptible to the pathogen. The disease can be especially destructive to susceptible California strawberry cultivars (e.g., Chandler, Camarosa, Albion) when grown on black plastic.	AFR appears as brown to black, water-soaked spots on green and ripe fruit. Firm, sunken brown to black lesions can develop over time depending on the prevalent relative humidity during disease development. Pink, salmon, or orange-colored masses of spores may form in the lesion under humid conditions, where the lesion may appear less sunken and brownish. Most cultivars' buds, pedicels, peduncles, and flowers are susceptible to *C. nymphaeae*. Flowers may also die and dry out. The pathogen can also wash down into the root zone and cause black lesions on roots. Infected tips can lead to widespread infections on young tissue of the plug plants and plant loss. Infected tissue placed in an incubation chamber will sporulate within 24 hours. The primary source of anthracnose inoculum enters strawberry transplant fields. Conidia are abundant on petioles, runners, and fruit and dispersed through rain splash, especially wind-driven rain. The movement of machinery and workers through the field may also contribute to inoculum spread. Warm, humid conditions are optimal for this disease, and overhead irrigation can also contribute to its spread.	fludioxonil fludioxonil + pydiflumetofen trifloxystrobin boscalid + pyraclostrobin azoxystrobin + propiconazole cyprodinil + fludioxonil pyraclostrobin + fluxapyroxad Fungicides play a major role in the management of this disease. Fungicide applications are critical in problem fields during early and full bloom. These fungicides are targeted to limit the build-up of the pathogen, even though symptoms are usually not visible. In research tests, the bloom sprays are critical; applying an efficacious fungicide when the first AFR symptoms occur on the fruit can lead to poor control; it takes 10 to 14 days to slow down an epidemic and protect new fruit once the disease starts on fruit. Growers must manage fungicides to avoid the development of resistant populations. Captan has good efficacy and is also routinely used for gray mold management as outlined above. The QoI fungicides are highly effective against	None effective	Sanitation practices, by picking dead fruit (SC)	Variety resistance. The use of disease-free plants is the most important management strategy for controlling this disease. Rapid detection methods for diagnosing anthracnose-infected transplants prior to planting are available but the main challenge is to understand how many plants need to be sampled to declare a plant lot as disease free. Resistant cultivars are available and breeding efforts have shown promise. For example, ‘Sweet Charlie’ is less susceptible to the fruit rot phase than other cultivars commonly grown on plastic. Periodic field scouting, especially during warm and wet weather, enables early detection of AFR. As soon as disease is discovered,

				Colletotrichum species, especially when combined or rotated with Captan. The relative efficacy of available fungicides in 2018 are highlighted in the table under the Botrytis section above.			immediate removal and destruction of infected and surrounding plants has worked to reduce inoculum levels. Avoidance of overhead irrigation as done in the plasticulture system limits conidial dispersal and spread of the pathogen. Excess nitrogen increases AFR and calcium nitrate sources for nitrogen is better than ammonium forms. Growers typically pick the infested area last and do not let personnel or equipment move from an infested area to clean areas in order to limit spread of the pathogen. Plants should not be worked when wet and hand sanitation work in the early spring (removing dead leaves, pulling weeds) should be avoided if C. acutatum is known to be present.
Black root rot (pythium spp., fusarium spp, rhizoctonia spp.)	Low	Black root rot is a disease complex on strawberry, meaning that one or more organisms can be involved in the infection, including the fungi		chloropicrin Fumigation: Pic-clor 60, Vapam, commercial applicants. Applied once a year to every other year, or every other year due to expense	None effective	4 year rotation (GA)	Site selection is a key management strategy. Most growers attempt to choose a site with adequate

		Pythium spp., *Fusarium*, spp., *Rhizoctonia* spp., and several species of nematodes. It is a common disease in North Carolina and is generally more severe in older (matted row) plantings, especially during dry weather and close to harvest. Infection usually sets in the first fruiting year and worsens the following year. Black root rot is enhanced by stresses like poor soil drainage, cold, drought, flooding, soil compaction and repeated freezing of roots. The pathogens can be isolated from plants raised in the plasticulture system but the impact on plant productivity is not well known. Above ground symptoms including lack of vigor leading to plant collapse may resemble red stele (caused by *Phytophthora fragariae*), but the root vascular tissue does not become discolored as in red stele. Plants may be stunted with small fruit, few runners, and numerous dead older leaves. Infected plants do not respond to fertilization or improved growing conditions, and yields may be reduced.		(GA). SC: small farms don't fumigate, too time consuming and costly for small acreage Most growers will pre-plant fumigate their soils to manage this complex. Any fumigant with adequate levels of chloropicrin have good efficacy. Approximately 90% of the acreage is treated fumigants.			aeration and drainage. Rotation out of strawberries at least every 3 years (4 year crop rotation in GA) into crops that are not hosts of Rhizoctonia spp. and Pythium spp. can be helpful. Recent research in North Carolina has documented that all strawberry transplants, despite the source, have these pathogens associated with their roots.
Charcoal rot (*Macrophomina phaseolina*)	Low	Charcoal rot was first reported in Florida in 2005. Infected plants wilt, are stunted, and eventually die. The disease affects the plant roots and crown, and it can be difficult to distinguish from other crown diseases.					
Fusarium wilts, blights, rots and damping-off	Emerging	Risk of Fusarium wilt being imported on		Treated the same as other leaf spots.	None effective	None effective	None effective

(*Fusarium spp.*)		transplants from CA and Canada. Long-term problem once infested					
Gray mold (*Botrytis cinerea*)	High	Gray mold is a serious disease in all strawberry production areas and is one of the primary diseases of concern in most years. The disease is a problem not only in the field but also during the storage, transit, and marketing of strawberries due to the onset of severe rot as the fruits ripen. Other parts infected by the fungus include leaves, crowns, petals, flower stalks, and fruit caps. Disease is most severe during bloom and harvest in seasons with lengthy periods of cloud and rain.	*B. cinerea* enters the field on transplant foliage and nearby decaying vegetation. The fungus can live in the green tissue but be latent, or dormant, and not cause symptoms. As the infected strawberry leaf begins to die, the pathogen goes into an active stage, colonizing the leaf and obtaining its nutrients from the dead tissue. Spores then form and, once environmental conditions are appropriate (between 65 to 75 °F and damp or rainy weather), they are dispersed by water splash and/or wind onto newly emerging leaves or blossoms. Immature fruits become infected primarily through blossom infections. Once the berries begin to ripen, the fungus can colonize them and sporulate, producing the mold often seen in the field. Botrytis can also affect many different crops; therefore, weeds surrounding a field could be an important source of the pathogen. The pathogen can also produce dark hardened structures called sclerotia and these can persist in soils for years. Based on North Carolina research, it appears most infections occur from initial inoculum on leaf and crown tissue moving with transplants. Therefore, the strains on transplants may be resistant to certain fungicides based on use in nurseries.	boscalid + pyraclostrobin captan cyprodinil + difenoconazole fenhexamid fludioxonil + pydiflumetofen fluxapyroxad + pyraclostrobin iprodione thiram trifloxystrobin cyprodinil + difenoconazole fludioxonil + pydiflumetofen boscalid + pyraclostrobin pyraclostrobin + fluxapyroxad cyprodinil + fludioxonil fenhexamid captan thiram iprodione thiophanate-methyl (not recommended because of widespread resistance). Strobilurins (not recommended because of widespread resistance). Fungicides are targeted to limit flower infection that leads to fruit infection; thus, limiting the need for late-season applications to the fruit. A few well-timed sprays are less costly and more effective in controlling gray mold than frequent fungicide applications through harvest. *B.*	No varieties are resistant, but those with reflexed calyxes are less susceptible as they do not trap water around the fruit. Biological control agents are largely ineffective.	Sanitation (SC), cleaning plants, timely harvest	B. cinerea is commonly associated with transplant leaves and two years of research has demonstrated that there are no differences due to plant source. Currently, it is not possible to obtain disease free plants. However, plug production practices may favor crown rot problems and excess use of certain fungicides during the propagating phase results in resistant populations and poor control with these fungicides in fruit production fields. Optimum fertility management is important since excess nitrogen has been shown to increase fruit rot when weather conditions are favorable. Increasing nitrogen levels beyond an optimum level does not increase yield but does increase fruit rot incidence. Optimum (for

						cinerea has developed resistance to all commercially available fungicides. Therefore, products with different modes of action must be mixed or rotated and used frugally. Captan and thiram have good efficacy, are broad spectrum products, and have no resistance issues.			yield/disease pressure balance) sufficient plant spacing improves airflow in the canopy. Planting in raised beds improves drainage and also increases airflow, resulting in lower disease levels. Plastic mulch helps keep down rain splash, plant and soil-surface contact, and weeds that may harbor Botrytis inoculum, and reduces moisture within the canopy. Drip irrigation provides a direct source of water and eliminates excess moisture on fruit and leaves. Removal of senescing tissue from the field may be helpful in the fall, but is of most benefit in the early spring, just prior to bloom, to help lower inoculum levels. Many growers do find it practical to remove senescent leaves as workers hand pull weeds and pull plants that grew under the plastic mulch. Harvested fruit is typically monitored for disease, and

							infected berries removed. Postharvest conditions e.g. keeping fruit at around 34 °F, are manipulated to keep gray mold incidence down.
Leaf spot (*Diplocarpon fragariae*)	Low	This fungus produces numerous purplish blotches of irregular shape and small size. Clusters of the blotches turn brown, but never white or gray as in the case of leaf spot. Dark glistening acervuli appear in the lesions on the upper surfaces of the leaves. In severe cases, the leaf margins curl upward and the leaves progressively dry to a tan color from the margins to the midrib.		captan DMI fungicides	None effective	None effective	Variety tolerances.
Leaf spot and fruit rot (*Neopestalotiopsis*)	High	Crop Stage: All year long	Below-ground symptoms were characterized by darkening of the roots and orange-brown necrosis in the crowns, which contributed to stunting or poor establishment after transplanting. Above-ground symptoms ranged from stunting to wilting and necrosis of older leaves, to eventual collapse and death of the entire plant. There has been a strong association with long periods of rainfall and spider mite infestations.	cyprodinil + difenoconazole cyprodinil + fludioxonil thiram difenoconazole Management options for this disease are limited.	None effective	Clean plants, sanitation (remove diseased plants).	
Phomopsis leaf blight and fruit rot (*Phomopsis obscurans*)	Low	Phomopsis leaf blight and fruit rot rarely occur but can be a serious problem on plants produced in the southeastern U.S. The initial infection spots of this fungus are larger than leaf spot. From one to five lesions may occur on a leaf. The lesions		captan DMI fungicides Treated the same as other leaf spots.	None effective	None effective	None effective

		are circular and reddishpurple at first. Mature lesions are zonate and dark brown in color, with a light brown to tan periphery ringed by a purple zone. The spots are frequently V-shaped with the widest part of the lesions at the leaf margin and the narrow base centered on a vein. Black specks (pycnidia) dot the central area of the older lesions. This fungus also affects fruit. Initial lesions appear as round, light pink, watersoaked areas on the surface. Lesions may coalesce. Infected areas turn brown and the entire fruit ultimately becomes infected.					
Phytophthora crown rot (*Phythophthora cactorum*)	Medium to High	Crop Stage: Establishment Strawberry infection by *P. cactorum* occurs on poorly drained, over irrigated soils, or during long periods of rain in warm climates. Symptoms of disease are enhanced during periods of high water need, such as after transplants are set, during hot dry weather, or as the fruit load increases. This disease was rare in the 90's but is more common and prevalent in North Carolina fields. In many cases, problems are associated with infected transplants. On some farms, the inoculum persists for years. Stunting of plants or wilting of young leaves are the first symptoms and may appear at any		chlorothalonil mefenoxam metalaxyl mefenoxam + oxathiapiprolin chlorothalonil + mefenoxam	None effective	Clean plants and sanitation.	Use of disease-free plants is the most important management strategy in North Carolina but sampling protocols are not available to optimize detection technologies prior to planting. Growers will also avoid poorly drained land or fields with a history of the disease.

		time during the season. Infected plants may remain stunted, or foliage may turn bluish and the entire plant may wilt rapidly until total collapse.					
Powdery mildew (*Podosphaera macularis*)	High in Some Locations	High for greenhouses and tunnels, variety specific. Crop Stage: tunnels and greenhouses Once infected with powdery mildew, strawberry leaf edges begin to roll upward, and a sparse white growth of conidia and conidiophores may be seen on the undersurface of the leaves. If the infection is severe, leaves may show purple blotches, or they may be killed. In central Florida, the disease is typically most severe in November and December and it may reappear in late February and March. Cultivars differ widely in their resistance to powdery mildew. Unfortunately, some of the most popular cultivars in Florida (Strawberry Festival, Camarosa, and Winter Dawn), are quite susceptible to the disease.		fludioxonil + pydiflumetofen myclobutanil quinoxyfen sulfur trifloxystrobin myclobutanil fludioxonil + pydiflimetofen (limited for greenhouses) trifloxystrobin quinoxyfen Controlled with DMI fungicides	None effective	Increasing moisture	None effective
Red stele (*Phytophthora fragariae*)	Low	Red stele is one of the most serious diseases of strawberry in matted row systems. There are numerous races of P. fragariae, and certain strawberry cultivars show varying degrees of resistance to some of them. However, no cultivar is resistant to all races, and the disease is recurrent in North	Diseased plants are generally aggregated in low, wet areas of a field and aboveground symptoms appear when temperatures warm, from March to July. Young foliage may appear bluish, but with age leaf tips become tinged with red, orange, or yellow discoloration. In hot, dry summer weather severely diseased plants become stunted and wilted. Plants	mefenoxam phosphorous acids, poly-, potassium salts mefenoxam + oxathiapiprolin Ridomil Gold is registered for red stele control and helps to reduce losses if disease develops in an established planting,	None effective		Growers will avoid areas of the field where red stele has been reported and avoid fields with poor drainage. Use of disease-free plants is important to limit the introduction of

		Carolina. This disease is rare in plasticulture systems.	may remain wilted even in the presence of adequate moisture, followed by collapse and death. Fruit size and runner production may be reduced. Diseased plants will have few new roots, and feeder roots may decay and fall off leaving a "rat-tail" appearance. The fungus is spread primarily by symptomless, infected planting stock, but may also be carried in surface water or contaminated farm equipment. Once established, the fungus may persist for many years in the absence of the strawberry host.	although Ridomil-resistant strains of *P. fragariae* have been isolated from strawberry fields. Application rates are 0.5 pound of active ingredient of Ridomil Gold with 2 to 3 applications per year. The product may be used on approximately 2% of the acreage for red stele control. Various phosphonates are also registered for control of red stele but rarely used.			the pathogen on any given farm. However, no diagnostic protocols are routinely available for detection of the pathogen on transplants. Resistant cultivars are available, but they are not resistant to all races of the pathogen.
Root rot/damping off (*Rhizoctonia spp.*)	Medium			azoxystrobin (applied in a band to cover crown and roots)	None effective		
Strawberry leaf spot (*Mycosphaerella fragariae*)	Low	Leaf spot or Mycosphaerella leaf spot is one of the most common leaf spot diseases of strawberry, but rarely reaches economic levels in North Carolina. Several California cultivars are very susceptible, especially when grown on black plastic. Symptoms begin as small round purple spots 1/8 to ¼ inches in diameter on upper leaf surfaces. Lesions may also develop on fruit (black seed), caps, fruit trusses, petioles, and runners, and can grow to 3 to 6 mm in diameter. On older leaves the center of the lesion changes from tan or gray to white, with reddish purple to rusty brown margins, while on younger leaves the lesions stay light brown. Leaves may die if numerous lesions coalesce. Usually the lower leaves die out. In		captan DMI fungicides Growers generally do not treat for this disease specifically, but broad-spectrum fungicides used to control other diseases also control this one. Use of protective fungicides is only necessary on highly susceptible cultivars and if common leaf spot symptoms are prevalent in the transplants. Some resistance to fungicides has been observed but not documented in the southern region.			Use of disease-free plants is the most important strategy to limit common leaf spot problems. Some northeastern cultivars have resistance to M. fragariae, but there are no resistant southeastern varieties. Growers sometimes use sanitation and heavily infected bottom leaves are removed to reduce inoculum pressure.

		North Carolina, the pathogen is most commonly imported on plants in North Carolina.					

Weeds

Weed control represents one of the major costs in strawberry production. Weeds reduce berry size and number by competing with the crop for nutrients, space, and light, and can interfere with harvest. They also make pick-your-own operations unsightly to customers (SC, NC, VA). Nationally, 64 genera of weeds have been identified as economically damaging in strawberries, and growers may spend more than five hundred dollars per acre to control weeds in many fields.

Weeds may harbor spider mites, thrips pests, and plant parasitic nematodes. The potential for pest reinfestation is not great when the weed grows from transplant holes in the plastic mulch because, in that position, miticide applications will kill resident mites on both the weeds and strawberry plants. However, if weeds also grow in the row ends and field perimeter, these areas are not treated. Consequently, spider mites and thrips can reinfest fields from these plants after miticide residues have decreased.

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Annual grasses	High in Some Locations	Goosegrass control is a high priority for FL growers		clethodim flumioxazin napropamide pendimethalin sethoxydim terbacil glyphosate (broad spectrum) Band application: clethodim sethoxydim paraquat		The use of polyethylene mulches enhances fumigant efficacy and also provides excellent control of grass and broadleaf weeds on the bed.	Weed-eater or hand-pulled.
Black medic (*Medicago lupulina*)	High in Some Locations	Serious issue in Florida					
Broadleaf weeds	Low			acifluorfen carfentrazone-ethyl clopyralid, monoethanolamine salt eptam fluazifop flumioxazin napropamide oxyfluorfen pelargonic acid sethoxydim terbacil		The use of polyethylene mulches enhances fumigant efficacy and also provides excellent control of grass and broadleaf weeds on the bed	
Canada thistle	Emerging	Brought in with soil.					

(*Cirsium arvense*)							
Carolina geranium (*Geranium carolinianum*)	High in Some Locations	Top weed species in Florida		clopyralid oxyfluorfen		Sanitation.	
Chickweed (*Stellaria media*)	Medium			flumioxazin sulfentrazone glyphosate clopyralid (slow down growth)		Hand pulling.	
Clovers ( )	Low			clopyralid			
Common chickweed (*Stellaria pallida*)							
Common ragweed (*Ambrosia artemisiifolia*)	High in Some Locations	Top weed species in Florida					
Corn spurry (*Spergula arvensis*)				sulfentrazone			
Curly dock (*Rumex crispus*)	High			glyphosate clopyralid (poor) In rows.		Hand Pulling (needle-nose).	
Dandelion (*Taraxacum spp.*)				clopyralid			
Eclipta (*Eclipta prostrata*)	Medium in Some Locations	Top weed species in Florida					
Goosegrass (*Eleusine indica*)	High in Some Locations	Top weed species in Florida. *E. indica* is a prolific seed producer and difficult to remove by hand, and dense populations occurred on farms where preemergence herbicides were applied. Preemergence applications early in the season do not provide season-long control. Populations with resistance to paraquat have been reported in Florida.		paraquat			
Green kyllinga (*Kyllinga brevifolia*)	Emerging	Emerging issue in Florida					
Horseweeds (*Conyza spp.*)	Emerging			flumioxazin			

Mouseear chickweed (*Cerastium spp.*)							
Nightshade ( )	Low			clopyralid			
Perennial grasses	Low			clethodim sethoxydim Band Application: paraquat			
Pigweed (*Amaranthus spp.*)	Emerging			flumioxazin napropamide			Mowing and weed-eaters.
Primrose, cutleaf evening (*Oenothera laciniata*)	High in Some Locations	Top weed species in Florida		flumioxazin oxyfluorfen sulfentrazone			
Ragweed parthenium (*Parthenium hysterophorus*)	Emerging	Ragweed parthenium is emerging serious issue with a need for management options.					
Red sorrel (*Rumex acetosella*)				clopyralid			
Sowthistle (*Sonchus spp.*)				clopyralid			
Vetch ( )	Medium			clopyralid			Hand weeding.
Wild mustard (*Sinapis arvensis*)	Low						
Wild radish (*Raphanus raphanistrum*)				flumioxazin			
Yellow and purple nutsedge	High in Some Locations	Purple (*Cyperus rotundus* L.) and yellow (*Cyperus esculentus* L.) nutsedge are the only species that can not only emerge in planting holes but also pierce the polyethylene mulch. Preemergence herbicides can suppress *Cyperus* spp., but fumigants are generally the most effective management option. For best control of nutsedge, soil must have enough moisture for tuber sprouting. Allow 10 to 14 days for nutsedge tuber sprouting to occur, and then lightly till to destroy shoots and dry the soil surface.		eptam glyphosate sulfentrazone Glyphosate (spot spray) Sulfentrazone (G-E, SC) Eptam (EPTC) will provide good control of yellow nutsedge when applied at least 45 days before transplanting strawberry. The best control strategy is to use Spartan (a.i. sulfentrazone), which provides excellent control of yellow nutsedge and reduces tuber viability. There are no POST herbicides registered in strawberry that will control emerged yellow nutsedge. Eptam can only be		Plastic.	

				applied in the fallow period; see label for application instructions and restrictions.			
Yellow woodsorrel (*Oxalis stricta*)				sulfentrazone			

Nematodes

No nematode-resistant strawberry varieties exist, and there are no post-plant remediation strategies available. Strawberries are susceptible to multiple nematode species. Sting nematodes and root-knot nematodes, with sting nematodes being by far the most severe (FL).

Strawberry production problems caused by sting nematode tend to occur in more or less definite areas where transplants fail to grow normally. Infested areas consist of spots that vary in size and shape, but the boundary between diseased and healthy plants is usually fairly well-defined. Initially, a field may have only a few such areas, which may then increase in size and number until the entire field becomes infested.

The effect on strawberries is to cause both stunting and decline, the intensity of which is related to the initial population level and the rates at which populations increase during strawberry crop growth. Affected plants become semi-dormant, with little or no new growth. Leaf edges turn brown, progressing or expanding from the edges to the midrib to include the entire leaf. Leaves seldom become chlorotic, although cases have been reported in which leaf yellowing occurs when essential nutrients are present in a limited supply. Since the outer older leaves die first, the plant gradually decreases in size and eventually may be killed. Nematode-infested plants are much more susceptible to drought conditions and injury from fertilizer salt accumulation.

Nematode management is viewed first and foremost as a year-round, programmatic activity requiring consideration of all cultural, chemical, and agronomic practices within the areas where strawberry plants are grown. Because strawberries must be vegetatively propagated and transplanted into the field, growers must first pay special attention to the source of strawberry transplants to ensure that they are not infested with nematodes (as well as mites, diseases, etc.). After the final harvest, the crop is destroyed as quickly as possible to remove nematode food sources. In most cases, delays in crop destruction contribute to greater nematode population increases and greater difficulty in achieving nematode management.

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Foliar nematodes (*Aphelenchoides*)	Low	*Aphelenchoides besseyi*, is a migratory facultative phytoparasitic and mycophagous nematode that infects aboveground plant parts and feeds on fungal mycelium. It was first described in 1942 as the cause of summer crimp disease in Florida and North Carolina strawberry fields. Foliar nematode infestations were common in the 1930s and became rare after that until 2016. In the 2016/2017 outbreaks, the primary inoculum source was traced back to a North Carolina nursery, the type locality of *A. besseyi*. It	These nematodes are migratory facultative phytoparasitic and mycophagous nematode that infects aboveground plant parts and feeds on fungal mycelium. They reproduce on both strawberries and the fungus *M. fructicola*.	fluensulfone fluopyram heat-killed burkholderia sp strain a396 cells and spent fermentation media			Nematodes are commonly spread by the movement of infested soil and/or infected plants by human activity. Sanitation and good cultural practices are the best preventive measures against nematodes. Obtain nematode-free transplants from reputable sources. Wash soil from machinery and tools before using them at another location. Nematodes may also be spread by wind, water, soil erosion, and animals. Some plants commonly used as cover crops are naturally suppressive

		was determined that *A. besseyi* is a species complex by analysis of molecular data for this popula- tion.					to certain nematode species, but no single crop is effective against all nematodes. The cover crop plant may be a nonhost, so the nematodes starve, reducing their population as with fallow.
Lesion nematode (*Pratylenchus spp.*)	Low						
Root-knot nematode (*Meloidogyne spp.*)	High in Some Locations	Species that can be found in strawberries include *Meloidogyne hapla, M. incognita, M. javanica, M. arenaria.* While *M. hapla* is more commonly found in strawberries in template climates such as NC and VA, all the other species can be found throughout the southeastern US. all the way down to FL strawberries. Root-knot nematodes (*Meloidogyne* spp.) (RKN) are the most common and destructive plant-parasitic nematodes globally. Although they tend to cause most damage in the tropics and sub-tropics, they are found in all agricultural regions worldwide. All root-knot nematodes are obligate sedentary endoparasites of plant roots and tubers, meaning that they enter the root and establish a feeding site from which they do not move. They induce small or large root swellings called root-knots or galls. Their infective second-	Both sting and root-knot nematodes can cause stunting of plants and reddening and yellowing of foliage. Sting nematodes tend to cause more damage earlier in the season, as soon as plants start producing fruit, whereas root-knot nematode damage more typically occurs towards the end of the season when soils are cooler. Root-knot nematodes can cause late season collapse of strawberries, but yield loss at this time has less of an economic impact, unlike the early season damage caused by sting nematodes.	1,3-dichloropropene chloropicrin plus mixed dichloropropenes fluensulfone fluopyram heat-killed burkholderia sp strain a396 cells and spent fermentation media			Nematodes are commonly spread by the movement of infested soil and/or infected plants by human activity. Sanitation and good cultural practices are the best preventive measures against nematodes. Obtain nematode-free transplants from reputable sources. Wash soil from machinery and tools before using them at another location. Nematodes may also be spread by wind, water, soil erosion, and animals. Some plants commonly used as cover crops are naturally suppressive to certain nematode species, but no single crop is effective against all nematodes. The cover crop plant may be a nonhost, so the nematodes starve, reducing their population as with fallow.

		stage juveniles (J2) hatch from the eggs in the soil and penetrate the tip of a suitable root where they develop into sedentary and swollen juveniles and adult females. Males are wormlike, not parasitic and exit the root when they reach adulthood in search of suitable females to mate with. All root-knot nematodes induce formation of specialized trophic sites (feeding sites) called giant cells that provide essential nutrients for their development and egg production. The formation of giant cells is associated with hyperplasia (enlargement) of the tissues surrounding the feeding site. Adult females produce many eggs (up to and often more than 1000) encased in a protective gelatinous matrix (Desaeger 2019).					
Sting nematode (*Belonolaimus longicaudatus*)	High	In general, growers are not having a serious nematode problem as fumigation takes care of most problems. Also known as the 'long-tailed' nematodes are native to the sandy coastal plains of the southeastern U.S. and are very widespread in FL strawberry fields. They are one of the largest plant-parasitic nematodes, measuring almost 1/10 inch long. They have a very long stylet, a hypodermic-like needle which is used to feed on	Feeding by this nematode kills the root meristem and halts root growth, which causes dark lesions on the roots. Lateral roots will develop, but *Belonolaimus longicaudatus* will migrate to these lateral roots and damage them as well. This causes an abbreviated and stubby-looking root system. Because the roots are damaged, they are unable to supply the plant with water and nutrients, becoming stunted, wilted, and eventually die.	1,3-dichloropropene chloropicrin plus mixed dichloropropenes fluensulfone fluopyram metam-potassium Crop rotation (4-5 yrs), chemical controls (fumigants), and cover crops as control methods 1,3-Dichloropropene (effective, but comes back as an issue for other crops) Pic-chlor 60, 10-20% yield harm possible. Because *Belonolaimus*	Fungal products: velum(preplant and in season, broadspectrum), majestene(preplant and in season), pic-chlor 60 (in season).		Sunn hemp has been shown to be resistant to *Belonolaimus longicaudatus* and may be used as a summer cover crop for suppression of *Belonolaimus longicaudatus* and other plant-parasitic nematodes in some situations. In strawberry it is important to kill off the plants after harvest so that they do not maintain the nematode population. Weed management is very important to eliminate

		strawberry roots, killing the root meristem and halting root growth. Lateral roots will develop, but the nematode will migrate to these lateral roots and damage them as well.		*longicaudatus* is an ectoparasite that spends its entire life in soil, it is among the most responsive plant-parasitic nematodes to fumigant and nematicide treatments. Despite this, it is difficult to manage with chemicals in certain systems due to its seasonal vertical migration.			all *Belonolaimus longicaudatus* hosts during fallow or rotation. Because *Belonolaimus longicaudatus* has no long-term survival stage, its numbers will rapidly decline from starvation during extended periods of clean fallow, or rotation with a non-host crop. However, the wide range of host plants for *Belonolaimus longicaudatus* makes it difficult to select non-host rotation crops or cover crops.

Mites

The most consistent arthropod pest of strawberries is the twospotted mite (*Tetranychus urticae*, Acari: Tetranychidae). While twospotted spider mites can be introduced on transplants, infestation usually develops in the field. Spider mites reproduce very quickly during warm weather. Spider mite infestation can reduce plant vigor and decrease yield.

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Broad mite (*Polyphagotarsonemus latus*)	Low	Female mites are about 0.2 mm long and oval in shape. Their bodies are swollen in profile and a light yellow to amber or green in color with an indistinct, light, median stripe that forks near the back end of the body. Males are similar in color but lack the stripe. The two hind legs of the adult females are reduced to whip-like appendages. The male is smaller (0.11mm) and faster moving than the female. The male's enlarged hind legs are used to pick	This pest causes terminal leaves and flower buds to become malformed. The mite's toxic saliva causes twisted, hardened, and distorted growth in the plant's terminal. Mites are usually seen on the newest leaves and small fruit. Leaves turn downward and turn coppery or purplish. Internodes shorten, and the lateral buds break more than usual. The blooms abort and plant growth is stunted when large populations are present. Fruit is discolored by feeding, and premature fruit	abamectin acequinocyl fenazaquin fenpyroximate potassium salts of fatty acids While various miticides are labeled for control of this pest, insecticidal oils or soaps are usually just as effective and less toxic to the environment.	For large area or greenhouse control, biological control agents are available, including several species of predatory mites, such as: • *Amblyseius swirskii* • *Neoseiulus californicus* • *G. occidentalis* • *N. cucumeris*		Hot water treatments may control the mites without injuring the plants. This involves dipping the plant into water held at 43 to 49°C (109.4-120.2°F) for 15 minutes.

		up the female nymph and place her at right angles to the male's body for later mating. The eggs are colorless, translucent and elliptical. They are about 0.08 mm long and are covered with 29 to 37 scattered white tufts on the upper surface, characteristic of the species.	drop may occur in severe cases. Broad mites have a wide host range in tropical areas, including strawberries in open fields. It attacks greenhouse plants in temperate and subtropical regions. There are also reports of the broad mite using insect hosts, specifically some whiteflies, to move from plant to plant.				
Cyclamen mite (*Phytonemus pallidus*)	High in Some Locations	Cyclamen mites are small, clear-bodied mites, ~0.25 mm in body length. Their eggs are also clear, oval, and have a smooth surface. Eggs are typically glued to the edge of the leaf trichomes or trichomes of the fruit calyx, typically on the underside. At 75 F, they develop from egg to adult in about three weeks. Adults prefer to feed on young foliage and are typically found on strawberry trifoliates that are still folded and developing near the crown. These mites are not visible to the naked eye. Adults can overwinter in the crown of strawberry, but in warmer climates, they can continue to reproduce through the winter. Coming from nurseries, found in	Feeding results in crinkled leaves, especially new unfolded and young leaves. Plants become stunted (compact leaf mass) until they eventually turn brown and die. Flowers can be damaged at high pest levels, resulting in browning and drying. Fruits may also be affected by feeding damage and will appear undersized. High densities may prevent fruit from being produced entirely. Cyclamen mite infestations usually originate from contaminated nursery stock. These mites can overwinter and resume activity in spring under warm temperatures (>55 F). When damage symptoms are observed, usually large populations are established. In	abamectin diazinon fenazaquin fenpyroximate Drench 500 gal per acre 100 PSI-50 gal per acre Prevention of pest infestation and pest establishment is a better tactic than crop rescue, because of the limited miticide compounds available and lack of effective pest suppression. Many miticides labeled for spider mites are not labeled for cyclamen mite management in strawberries. Economic threshold for cyclamen mites in NC is one trifoliate in 10 sampled show cyclamen mites. Folded leaves deep in the crown of the plants must be sampled to have an acceptable estimate of cyclamen mite infestation.	Commercially available generalist phytoseiid mites such as *Neoseiulus californicus* and *Neoseiulus cucumeris* have been shown to control phytophagous mites on strawberries, as well as the naturally occurring predatory mite, *Neoseiulus fallacis.*	Electrostatic spray, air system sprayer	Research conducted using hot water treatments found that soaking cyclamen mite-infested strawberry seedlings at 46 C (114 F) for 6.5 min killed the mites. Plugs grown in the greenhouse or nursery should be examined with a 10x hand lens before transplant to ensure they are free of mites. Growers are encouraged to obtain spray records from nursery and plant producers, in order to avoid making applications of miticides that were used in the nursery to plants in the field as this increases the risk of TSSM developing resistance to these materials. **Scouting:** spring mite scouting should begin in February or early March. Continue to monitor for mites, especially on older, lower leaves, at least every 2 weeks. Where previous cyclamen mite

		crown, hard to reach with chemicals, causes crinkling and looks like a pathogen, stunts growth	Virginia, strawberry plants have demonstrated the ability to recover from moderate levels of plant damage.				infestations have been reported, leaves should be checked weekly. Sample leaves by walking a V-shaped pattern in the field and stopping at 5 to 10 locations. Because of the small size of the mites, a 10x or 20x may not be enough to check leaves. Five folded leaves should be collected and sent to an Extension office of ID lab for examination. Information should be recorded on a field map so that hot spots can be watched closely.
Twospotted spider mite (tssm) (*Tetranychus urticae*)	High	TSSM is the most consistently occurring pest of open-field and high tunnel strawberry. Adults and nymphs are round, about 0.35 to 1 mm long; have two large dark areas on their abdomen, and have variable body colors including red, orange, green, and yellow. Adult males can be distinguished from females by the conical end of their abdomen and the larger size of females. TSSM have needle-like piercing-sucking mouthparts. TSSM overwinter as females that often turn orange or red colored. These mites become reproductively active when temperatures reach approximately 50 °F, and increase their activity as temperature increases.	TSSM pierce the leaf epidermis and extract sap. Adults and nymphs typically develop on the lower side of leaves where they can form complex webbing. Feeding causes pale chlorotic spots, known as stippling, to appear on the leaves. Heavily infested leaves turn light yellow or brown, starting on the edges, and eventually dry up. The undersurfaces of heavily infested leaves will be covered with silken webs over which mites crawl.	acequinocyl bifenazate cyflumetofen fenazaquin hexythiazox rosemary oil spiromesifen fenpyroximate (F-G, Nymphs) abamectin (F-G, not great for adults) etoxazole (G, eggs) bifenthrin (not recommened) Miticides are frequently used to control TSSM populations and can be used to treat hot spots across the field. Excellent coverage is necessary to get the most benefit out of a miticide application. Typically, a relatively high spray volume (100 gal per acre or more) and pressure is needed to achieve excellent coverage. Different conventional and organically	*Phytoseiulus persimilis (*CA, SC-mixed results). *N. fallacis, N. californicus,* recurrent releases *(FL)* Several species of predatory mites are available commercially, with *Phytoselius persimilis* being the most commonly used in strawberries. Because this predator only feeds on spider mites, *P. persimilis* requires spider mites to feed on, so preventative releases are not recommended. Generalist predatory mites that feed on multiple mite and insect prey can be released as a preventative tactic. The most used generalist predatory mite released on strawberries is *Neoseiulus californicus*. It can feed on other pest	Washing, row-cover scouting issues.	Varieties-Resistance, elimination of host plants Isolation or rotation of strawberry beds 100 yards or more away from mite-infested fields helps to prevent mites from becoming established. Destruction of broadleaf weeds around the field in fall or early spring reduces the overwintering population. During the growing season; however, this strategy will force mites to migrate into the field. Some cultivars, such as ‘Selva’, show a high level of susceptibility to TSSM. ‘Chandler’ is somewhere in the middle. Cultivars commonly grown in North Carolina are not resistant to spider mites. **Scouting**. Plugs grown in the greenhouse or nursery should be examined with a 10x hand lens before

			Each female can produce up to 19 eggs per day and over 100 eggs. The number of eggs laid depends on temperature, and the eggs have an incubation period of 3 to 19 days, depending on temperature. Development is most rapid during hot, dry weather.		acceptable miticides are registered for strawberries, and they differ in mode of action, application rates, and efficacy against TSSM's life stages. Acramite, Agri-Mek, and Zeal are the most commonly used miticides in North Carolina. Growers are discouraged from using pyrethroid insecticides to manage spider mites because they are only active against the adults and frequently result in higher populations after treatments because they are toxic to natural enemies. Thresholds vary depending on the stage of the crop. Older plants in the harvest stage can tolerate higher numbers of TSSM than young plants: • Fall= 20 spider mites/trifoliate • Spring= 30 spider mites/trifoliate • Harvest= 60 spider mites/trifoliate Another threshold available for TSSM recommends action when 25% infestation of a 60-leaf sample occurs or mite counts average 5 per leaflet. Then chemical control may be warranted. If mite populations are not high enough to require treatment before harvest in North Carolina, it is unlikely that a miticide treatment will be	mites like cyclamen mites and thrips to a lesser extent. Some growers release a mix of *N. californicus* early in the season and *P. persimilis* later in the season in case of an increase in TSSM. Predatory mite release rates vary based on TSSM populations. Some predatory mites can be released in the fall and can overwinter in fields and tunnels, or they can be released when spider mite populations are observed in spring. While some chemical controls are compatible with predatory mites, caution should be used when combining biological and chemical controls. Pyrethroid insecticides (IRAC Group 3) are toxic to predatory mites. Many organically acceptable materials, such as M-Pede, EcoTec, and horticultural oils, are as toxic to predatory mites as they are to spider mites. Growers interested in combining organic insecticides and predatory mites should use miticides before predatory mites release or plan to re-release mites at least five days after application.		transplant to ensure they are free of mites. Growers are encouraged to obtain spray records from nursery and plant producers, in order to avoid making applications of miticides that were used in the nursery to plants in the field as this increases the risk of TSSM developing resistance to these materials. Because early-season populations cause the greatest reduction in yield, spring mite scouting should begin in February or early March. Continue to monitor for mites, especially on older, lower leaves, at least every 2 weeks. When hot, dry conditions prevail, leaves should be checked weekly. Sample leaves by walking a V-shaped pattern in the field and stopping at 5 to 10 locations, where the undersides of five leaves should be examined for the presence or absence of two-spotted spider mites. Information should be recorded on a field map so that hot spots can be watched closely.

				beneficial. Typically, mite populations are present and cause the most damage before the beginning of harvest. TSSM management is most effective when undertaken early in the growing season when populations are small.			

Wildlife

Bird predation of strawberries used to be viewed as sporadic, but in three of the last four years, bird predation losses have been substantial. The species primarily associated with this phenomenon are American robins, cedar waxwings, and crows. These birds are estimated to cause losses of up to 400,000 flats of strawberries (over $2 million in losses). Flock presence draws in more birds.

Pest	Rank	Description	Symptoms	Chemical Control	Biological Control	Physical Control	Cultural Control
Crows (*Corvus spp.*)	Medium in Some Locations	Rank: High-medium (first 10 days), low rest of season (FL).				Air cannons, shooting, flappy men and lights (moving them around).	
Deer	High	Deer numbers are increasing or already very high in some areas, and incidents of deer damaging crops are also increasing. Deer populations are increasing across most of their range. Hunting on neighboring properties can reduce local damage but neighboring hunting clubs may be actively working to increase deer populations. Hunters should be encouraged to harvest does as opposed to bucks to have much of an impact on deer populations. Most state wildlife departments provide out-of-hunting-season deer depredation permits for producers with a documented deeer damage problem. Producers should contact their state wildlife agency for information on	Damage small fruit plantings by foraging on succulent new growth during the growing season or by eating fruit. Deer can also puncture plastic mulch and possibly the irrigation tape underneath, resulting in loss of weed control.	thiram Both taste and smell repellents are available for use. Smell repellents include commercially available products or materials such as tankage, blood, putrified egg solids, and certain soaps. While these products may be effective in the short term, repellents will not provide long-term control and will not provide control when populations are high or alternate food sources are scarce. Repellents, such as biosolids (for example, Milorganite® and chicken litter), are also effective. All repellents are biodegradable and need to be applied regularly and after rain or irrigation. Some repellents are not labeled for use on products	Meligmanite	Fences (strong cattle style, high), strobe lighting, wavy men, speakers, reflection tags, electric fencing, peanut butter on an electric fence, 2 tired poly taped fences, aluminum foil, and row covers. Exclusion (fencing) is the only truly effective long-term control for deer damage prevention. Fences can be electrified or not. Deer will try to go under a fence, through a fence, or over it. For non-electrified fences, the	

			depredation permits.		intended for human consumption (for example, repellents with rotten or “putrified” egg as the active ingredient). Please read product labels carefully and use products as instructed.		lowest wire needs to be within 10 inches or less of the lowest point in the ground around the fruit crop planting and tight enough to prevent deer from pushing under it. Do not neglect ditches or other low spots in the ground around the field, because the deer will find them. While some deer can easily clear an 8-foot fence, generally, 6 feet will be sufficient to deter most deer. Wire mesh fences are more desirable than multiple strands of barbed wire. Wire mesh fence up to 5-feet high with the addition of 3 single strand wires for a total of 8 feet will reduce costs. Slant wire fence is another design - see paragraph below. Standard vertical fence with outriggers may be useful. Contact the extension specialist for details on fence design. For electric fences, several different designs have been used and, under		

						certain conditions, each can be effective. The simplest and least expensive electric fence uses a single high-tensile wire at about 30 inches above ground level (approximately at the height of a deer's nose). A solar charger can be used if access to electricity is not an option.	
Fox ( )	Emerging					Low electric fence.	
Geese	Low	Crop Stage: land prep-planting				Flagging tape, decoys (coyote), keeping it dry.	
Hog (feral)	Emerging					Trapping, shooting.	
Rodents	Medium		Voles cause problems in strawberry fields by feeding on the roots and crowns of plants and by chewing holes in irrigation tapes under the plastic cover of raised beds.	There are no rodenticides labeled for use in strawberries. However, practices utilized in preparing fields for plasticulture strawberries should rid the area of any resident vole populations.		Trapping.	Habitat modification practices such as cleaning up nearby fencerows, ditch banks and hedgerows, along with frequent, close mowing of vegetation surrounding the fields, will discourage vole presence as a result of increased exposure to predators. Maintaining a barrier of very closely mowed vegetation around the perimeter is one option. Another option is to maintain a bare-soil perimeter around the fruit

							crop if that can be done without increasing erosion risks. Seasonal disking or herbicide treatment can maintain bare-soil perimeter seasonally.
Slugs (*Limax maximus*)	Low	Slugs overwinter in protected areas in the field and favor moist environments, such as those provided by heavy mulching and dense plantings. During the day, slugs are likely to be found in moist or damp places under boards, debris or stones. Slugs typically feed at night on any above ground plant part, but the most significant damage is to the fruit. Slugs are mollusks, not insects. They are slimy, legless creatures requiring high moisture to survive. Unlike snails, slugs have no shell. The gray garden slug is basically whitish, cream or flesh colored, has gray spots and measures 2 to 5 cm. Spotted garden slugs range from about 1 to 7 inches. When small, they tend to be dark, but larger slugs are yellowish gray or brown with conspicuous spots. Slug and snail damage is more common in greenhouse and high tunnel strawberry plantings or in outdoor plantings with poor drainage. Mature slugs may lay eggs anytime during the warmer months. The immature slug resembles the adult but is smaller, and is usually dull white. Newly hatched slugs may	Foliar injury usually appears between veins, on leaf margins or on petals. Small slugs merely rasp away the leaf or petal surface. Larger ones leave sizeable holes in leaves, petals and fruit and along plant margins. A silvery slime trail is usually left behind as evidence.	Chemical controls consist of toxic baits, which should be placed when slugs and snails are actively foraging on warm nights. Two or more treatments at 5 to 7 day intervals may be necessary to obtain adequate control		Manual removal.	Ensuring sites are well drained and well ventilated to reduce humidity will discourage slug presence. Elimination of breeding and hiding places can be helpful. Trimming course grass and weeds along fences and ditches in the vicinity of susceptible crops is also advisable. Strategies used for weed management may conflict with slug control tactics. For example, excessive amounts of mulch and closely spaced plantings encourage slug infestation.

		require a year to develop to maturity; however, under optimum conditions development may proceed faster.					

BIOLOGICAL CONTROLS

Natural enemies (predators and parasitoids), such as ladybugs and lacewings, can be introduced or encouraged to control pests like aphids. **Ladybug** immatures and adults are voracious predators of aphids and can fly long distances in search of aphid populations. Similarly, **lacewing** immatures prey on aphids. They are commonly known as trashbugs, and their stalked eggs are a clear indication of their presence. **Predatory mites** can move naturally to strawberry fields, especially after spider mite populations are starting to increase. Natural populations of *Neoseiulus fallacis* and *Phytoseiulus persimilis* have been reported in VA, NC, and SC. Additionally, commercially available predatory mites such as *P. persimilis* and *Neoseiulus californicus* are often released separately or in combination in strawberry fields for the control of mite and insect pests.

- *Phytoseiulus persimilis* is an obligatory predator of tetranychid mites (spider mites), such as twospotted spider mites, and will not feed on any insect pests, or any other mites outside Tetranychidae.
- *Neoseiulus californicus* is a generalist predatory mite that can feed on various insect and mite pests, including twospotted spider mites, cyclamen mites, and thrips and whiteflies to a lesser extent.
- *Neoseiulus cucumeris* is a generalist predatory mite that prey mostly on thrips species, and can also feed on spider mites and other smaller mite pest species.

When releasing predatory mites in strawberries, consider the following:

- Before release, check that predatory mite containers are in good condition (unbroken, without humidity accumulation). Additionally, check the mites for movement and signs of activity. If mites are not moving, something may be wrong with your product and can impair biological control in the field.
- Release your predatory mites as soon as delivered. If storing is necessary, store the product as instructed in the product instructions.
- Avoid releasing predatory mites in the hottest hours of the day (>90F) or below 60F. Warm mornings or warm late afternoons are ideal for release.
- Avoid high winds when releasing predatory mites if using bottle carriers or blowers for release.
- Some selective chemicals can be used together with predatory mites. When releasing predatory mites, make sure to release them at least five days after any pesticide application to avoid any potential harmful effects. Read the label carefully to learn more about the selectivity of the pesticides used. Some labels now include compatibility potential with biocontrol agents.
- Insecticides and miticides are not the only chemicals that can harm predatory mites. To safeguard your natural enemies, minimize pesticide sprays as much as possible.

Habitat manipulation involves providing or protecting vegetation in an agricultural area so that natural enemies can benefit from the food and shelter offered by this vegetation. Creating or preserving habitats for natural enemies of pests, can contribute to natural enemy establishment and pest suppression. Planting flower strips or flowering edges around the crop is a common way to promote natural enemy and pollinator establishment. For instance, **parasitoid wasps**, such as *Aphidius colemani* or *Aphidius ervi*, can be promoted with habitat manipulation or releases of commercially available parasitoids to manage aphids. Similarly, flowering plants such as sweet alyssum can be used to attract **syrphid flies** and predatory bugs such as **minute pirate bugs** (*Orius* spp.) that also feed on aphids.

Other less commonly used biocontrol options include:

Beneficial nematodes, such as *Steinernema feltiae* and *Heterorhabditis bacteriophora,* can infect and kill armyworms and cutworms infesting strawberries. The nematodes introduce bacteria that quickly kill the host and feed on the bacteria and the decaying pest.

Entomopathogenic fungi, like *Metarhizium anisopliae* and *Isaria fumosorosea*, can be useful against whiteflies and aphids, especially in organic strawberry production. These fungi infect and kill the pests upon contact. The spores germinate and penetrate the insect's body. Similarly, *Beauveria bassiana* can be applied as a biological control agent against thrips.

Bacterial-based bioinsecticides, such as *Chromobacterium subtsugae,* have insecticide and miticide properties that can be used on organically certified strawberries against twospotted spider mites.

Biological control methods are vital tools in the IPM toolkit for strawberry growers. By leveraging these biological agents, growers can reduce their reliance on chemical pesticides, promoting more sustainable and eco-friendly agricultural practices. For more information about biological control and a source of trustworthy providers, visit A Guide to Natural Enemies in North America or Guidelines for Purchasing and Using Commercial Natural Enemies in North America.

CULTURAL CONTROLS

Site Selection and Preparation: Site selection is one of the ways growers manage weeds to avoid planting or rotating strawberries into fields where existing weeds are difficult to control, especially those with high populations of perennial weeds. Because the location is desirable, some growers who use the plasticulture system use the same field each year to produce strawberries. This can lead to an increased population of weeds that are not being controlled by the herbicides registered in strawberries. In matted row production systems, growers sometimes cultivate the field one or two years before planting. Plowing, disking, or rotovating can significantly reduce annual and some perennial weed problems. Cover crops can be established in the field for one year before planting strawberries to suppress weeds in perennial systems. Rotating strawberries with unrelated crops, such as grasses and grains, can provide significant weed suppression.

Hand weeding and hoeing - Removing weeds by hand is the most common nonchemical control strategy for removing weeds that have escaped fumigation, herbicides, and cultivation. Many growers will have crews hoe newly planted beds in perennial systems and hand-pull emerging weeds out of the plant hole in the plastic mulch in the annual systems. In annual strawberries, growers currently hand-pull weeds two to three times during the growing season. It is important to remove weeds when they are small to avoid disturbing the strawberry root system. If weeds are large they should be removed by cutting the stem at the soil surface. Hand removal of some weeds including perennial nutsedge and vetch species is difficult and ineffective if the complete plant (including tubers for perennial nutsedge) is not removed.

Cultivation between rows - Cultivating (with a cultivator or rototiller) provides effective control of weeds during the establishment and renovation phases of matted row systems. Cultivation in plasticulture row middles has been widely adopted in organic fields. It is also increasingly being adopted in conventional fields in Florida and most states in the region.

Mulches: Mulches help control most annual weeds but are less effective for suppressing perennial weeds, including nutsedge species.

1. Plastic mulch is the most cost-effective nonchemical strategy for weed control. Black plastic mulch suppresses weed growth and is routinely combined with fumigation.

2. Organic mulches are helpful in suppressing weeds between beds during the growing season beginning the second year in matted row systems. Growers take care to ensure straw mulch is free of excess or new weed seeds to prevent volunteer weeds from emerging. Organic mulches are also used in annual systems between the plastic beds.

3. Living mulches or cover crops, such as annual ryegrass, are commonly established between plastic mulched beds in the fall and killed with an herbicide in the spring to reduce weed emergence and limit erosion.

Non-Chemical Pest Insect and Mite Control:

The principal non-chemical control measure is the purchase and release of beneficial predatory mites to manage spider mites. Over forty percent of Florida strawberry production is under this practice, which saves about four miticide applications per season. Other non-chemical measures include using resistant varieties, purchasing or planting certified pest-free plants, and sanitation. All growers scout for insect/mite pests and the majority apply a control measure (often chemical) when they believe a pest/damage threshold has been reached.

Non-Chemical Nematode Control:

The fact that all populations of sting nematodes have such a wide host range, including numerous weeds and grasses, must be considered in developing programs such as crop rotation systems for nematode management. Cover crop rotations with American jointvetch, hairy indigo, or sunn hemp have been shown to reduce sting nematode populations. In addition to sting nematode suppression, hairy indigo has also been reported to be resistant to several root-knot nematode species. Field following, particularly when coupled with early crop destruction, generally reduces total nematode densities in soil.

Non-Chemical Disease Control:

Non-chemical control strategies include planting certified plants, using resistant varieties, crop rotation, irrigation management, sanitation/destruction, and the use of plastic mulch. However, their use alone or in the absence of fungicides would result in severe losses. Non-chemical methods must be considered as tools that, in the presence of all other factors at a given time, add effectiveness to the overall disease management program. Growers may plant multiple varieties of strawberries to reduce the risks posed by various diseases and pests, and also take advantage of market conditions. Certain varieties show select disease resistance.

Non-Chemical Weeds Control:

Florida strawberries are grown in fumigated raised beds covered with plastic mulch. The plastic generally suppresses certain annual weed populations; however, external borders of the mulch and transplant holes allow weeds to germinate. Hand weeding may be used for these areas, but it is time-consuming and costly.

Row Covers are used to avoid leaf damage and flower drop by freezing temperatures during the winter. When freeze alerts are in place, row covers are usually placed during the day to allow the sunlight to create a warm microclimate under the cover and protect the plants from freezing temperatures below 26 F, often encountered at night or dawn. Row covers can also protect plants from certain pests, such as the tarnished plant bug (Lygus spp.), while allowing light and water to reach the plants.

Traps can be used to monitor pest populations. Yellow and white sticky traps can monitor small-bodied insects such as whiteflies, thrips, tarnished plant bugs, and clipper beetles. Also, buckets with ripened fruit can be used as attractants for sap beetles on the edges of the field during the harvest stage. Buckets must be removed to check the number of beetles and avoid accumulation.

TIMELINES

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

Crop Rotation						x	x	x					
Fertilization	x	x	x	x	x	x				x	x	x	February until June (all stages except for FL). Starting in October in FL until the end of the season
High Tunnel Greenhouse	x	x	x	x					x	x	x	x	NC, SC, GA
Organic And Sustainable Production	x	x	x	x					x	x	x	x	
Pest-Free Transplants									x	x			
Removal/Rouging						x	x	x					
Site Selection And Preparation								x	x				
Strawberry Cultivars													

Pests	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Aphids (strawberry aphids, potato aphids, green peach aphids) (Insects)		x	x	x	x								Feb-May (VA)
Brown marmorated stink bug (Insects)					x								
chilli thrips (Insects)	x	x	x	x	x			x	x	x	x	x	Lower activity in December but come back in middle of January. In FL, they can infest seedlings as soon as 1 week after transplant
Florida flower thrips (Insects)			x	x	x	x							Mar-Jun (VA, NC, SC)
Spotted-wing drosophila (SWD) (Insects)				x	x	x			x	x			Apr-Jun (NC, SC, VA), Sep-Oct under greenhouses
Strawberry bud weevil, Strawberry Weevil, Clipper Beetle (Insects)			x	x	x								(NC, VA)
Tarnished plant bugs (Lygus bugs) (Insects)				x	x	x	x						Mar-Jun (NC, VA)
Pepper thrips (Insects)													Unknown
Western flower thrips (WFT) (Insects)			x	x	x	x							Mar-Jun (VA)
Common blossom thrips (Insects)			x	x	x	x							Mar-Jun (VA)
Anthracnose fruit rot (Pathogens)									x	x	x		
Angular leaf spot of strawberry (Pathogens)													
Anthracnose crown rot, species complex (Pathogens)									x	x	x		
Charcoal rot (Pathogens)													
Fusarium wilts, blights, rots and damping-off (Pathogens)									x	x	x		
Gray mold (Pathogens)				x	x								
Phomopsis leaf blight and fruit rot (Pathogens)				x	x								
Leaf spot (Pathogens)													
Powdery mildew (Pathogens)		x	x					x	x	x			Tunnels and greenhouses
Red stele (Pathogens)	x	x	x	x							x	x	
Root rot/damping off (Pathogens)													
Strawberry leaf spot (Pathogens)													
black medic (Weeds)													
Canada Thistle (Weeds)													
Carolina geranium (Weeds)													
Chickweed (Weeds)													

Clovers (Weeds)													
Common chickweed (Weeds)													
Corn spurry (Weeds)													
Curly dock (Weeds)													
Dandelion (Weeds)													
eclipta (Weeds)													
goosegrass (Weeds)													
green kyllinga (Weeds)													
Horseweeds (Weeds)													
Mouseear chickweed (Weeds)													
Nightshade (Weeds)													
Pigweed (Weeds)													
Primrose, cutleaf evening (Weeds)													
common ragweed (Weeds)													
ragweed parthenium (Weeds)													
Red Sorrel (Weeds)													
Sowthistle (Weeds)													
Vetch (Weeds)													
wild mustard (Weeds)													
Wild radish (Weeds)													
Yellow woodsorrel (Weeds)													
Crows (Wildlife)									x	x			
Deer (Wildlife)	x								x	x	x	x	
Fox (Wildlife)	x	x	x	x							x	x	
Hog (feral) (Wildlife)	x	x	x	x	x	x	x	x	x	x	x		
Rodents (Wildlife)													
Slugs (Wildlife)				x	x					x	x		
Foliar nematodes (Nematodes)													
Lesion nematode (Nematodes)													
Root-knot nematode (Nematodes)													
Sting nematode (Nematodes)													
Broad mite (Mites)				x	x	x							Mar-Jun (NC, VA)
Cyclamen mite (Mites)	x	x	x	x	x	x				x	x	x	Mar-Jun (NC, VA). Symptoms show up in spring but mites were likely there from nursery
Twospotted spider mite (TSSM) (Mites)	x	x	x	x	x	x	x	x	x	x	x	x	Oct- Jun (FL, NC, VA), GA (Winter, under row covers), SC (Transplant)

Stages	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Nursery													temp
Nursery													
Nursery													
Nursery													
Planting									x	x			VA, NC, SC, GA
Planting										x			FL

Planting													
Planting													
Dormant	x										x	x	VA 3x Month (November-January)
Dormant	x											x	NC, SC, GA 2 months (December-January)
Dormant													FL no dormancy
Vegetative Growth		x	x										VA, NC, SC, GA
Vegetative Growth										x	x		FL
Vegetative Growth													
Preharvest			x	x									VA, NC, SC, GA
Preharvest									x	x	x		FL
Preharvest													
Harvest				x	x	x							VA, NC, SC, GA
Harvest											x	x	FL
Harvest	x	x	x										
Post Harvest	x	x	x									x	FL
Post Harvest					x	x							VA, NC, SC, GA
Post Harvest													
Post Harvest													

Chemicals	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
1,3-Dichloropropene + Chloropicrin (Fumigant)													
Allyl isothiocyanate (Fumigant)													
Chloropicrin (Fumigant)													
Dimethyl disulfide (DMDS) (Fumigant)													
Metam-Potassium (Fumigant)													
Metam-sodium (Fumigant)													
Aluminum tris(O-ethylphosphonate) (Fungicide)													
Azadirachtin (Fungicide)													
Azak (Fungicide)													
Azoxystrobin (Fungicide)													
Bacillus subtilis GB03 (Fungicide)													
boscalid (Fungicide)													
boscalid + Pyraclostrobin (Fungicide)													
Captan (Fungicide)													
Chlorothalonil (Fungicide)													
Cyprodinil (Fungicide)													
Cyprodinil + Difenoconazole (Fungicide)													
Cyprodinil + Fludioxonil (Fungicide)													
Dodine (Fungicide)													
Fenhexamid (Fungicide)													
Fludioxonil (Fungicide)													
Fludioxonil + Pydiflumetofen (Fungicide)													

Fluxapyroxad + Pyraclostrobin (Fungicide)													
Fosetyl-Al (Fungicide)													
Hydrogen peroxide (Fungicide)													
Iprodione (Fungicide)													
Mefenoxam (Fungicide)													
Metalaxyl (Fungicide)													
Myclobutanil (Fungicide)													
Peroxyacetic acid (Fungicide)													
Phosphorous acids, poly-, potassium salts (Fungicide)													
Polyoxin D zinc salt (Fungicide)													
Potassium bicarbonate (Fungicide)													
Propiconazole (Fungicide)													
Pyraclostrobin (Fungicide)													
Pyrimethanil (Fungicide)													
Quinoxyfen (Fungicide)													
Reynoutria sachalinensis (Fungicide)													
Rovral (Fungicide)													
Sulfur (Fungicide)													
Thiophanate-methyl (Fungicide)													
Thiram (Fungicide)													
Tilt (Fungicide)													
Topsin (Fungicide)													
Trichoderma harzianum (Fungicide)													
Trifloxystrobin (Fungicide)													
Triflumizole (Fungicide)													
Acifluorfen (Herbicide)													
Carfentrazone-ethyl (Herbicide)													
Clethodim (Herbicide)													
Clopyralid (Herbicide)													
Clopyralid, monoethanolamine salt (Herbicide)													
Dacthal (Herbicide)													
Eptam (Herbicide)													
Fluazifop (Herbicide)													
Flumioxazin (Herbicide)													
Glyphosate (Herbicide)													
Napropamide (Herbicide)													
Oxyfluorfen (Herbicide)													
Paraquat (Herbicide)													
Pelargonic acid (Herbicide)													
Pendimethalin (Herbicide)													
Sethoxydim (Herbicide)													

Sulfentrazone (Herbicide)													
Terbacil (Herbicide)													
Acequinocyl (Insecticide)													
Acetamiprid (Insecticide)													
Azadirachtin (Insecticide)													
Bacillus thuringiensis (Bt) (Insecticide)													
Bifenthrin (Insecticide)													
Buprofezin (Insecticide)													
Carbaryl (Insecticide)													
Chlorantraniliprole (Insecticide)													
Chlorpyrifos (Insecticide)													
Cyantraniliprole (Insecticide)													
Diazinon (Insecticide)													
Endosulfan (Insecticide)													
Fenpropathrin (Insecticide)													
Flonicamid (Insecticide)													
Flupyradifurone (Insecticide)													
Imidacloprid (Insecticide)													
Imidacloprid + lambda-Cyhalothrin (Insecticide)													
Malathion (NO INERT USE) (Insecticide)													
Methoprene (Insecticide)													
Methoxyfenozide (Insecticide)													
Naled (Insecticide)													
Neem oil, clarified hydrophobic (Insecticide)													
Novaluron (Insecticide)													
Potassium salts of fatty acids (Insecticide)													
Pyrethrins (Insecticide)													
Pyriproxyfen (Insecticide)													
Spinetoram (amixture of spinetoram-J and spinetoram-L) (Insecticide)													
Spinosad (Insecticide)													
Sulfur (Insecticide)													
Thiamethoxam (Insecticide)													
Tolfenpyrad (Insecticide)													
Abamectin (Miticide)													
Acequinocyl (Miticide)													
Beauveria bassiana GHA (Miticide)													
Bifenazate (Miticide)													
Cyflumetofen (Miticide)													
Diazinon (Miticide)													
Etoxazole (Miticide)													

Fenazaquin (Miticide)													
Fenpyroximate (Miticide)													
Hexythiazox (Miticide)													
Potassium salts of fatty acids (Miticide)													
Pyrethrins (Miticide)													
Rosemary oil (Miticide)													
Spiromesifen (Miticide)													
1,3-Dichloropropene (Nematicide)													
Azadirachtin (Nematicide)													
Chloropicrin plus mixed dichloropropenes (Nematicide)													
Fluensulfone (Nematicide)													
Fluopyram (Nematicide)													
Heat-Killed Burkholderia sp strain A396 cells and spent fermentation media (Nematicide)													
Metam-Potassium (Nematicide)													
Chlorophacinone (Vertebrate Control)													
Iron phosphate (FePO4) (Vertebrate Control)													
Thiram (Vertebrate Control)													

Worker Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Fumigation								x	x				
Mulching								x	x	x			
Transplanting									x	x			Sept-Oct (VA,NC), Sept-Oct (FL), Oct (SC,GA), (October is ideal, depending on plant availability)
Freeze Protection	x	x	x								x	x	VA, NC, SC, GA, and few days in FL
Irrigation System Maintenance	x	x	x	x	x	x			x	x	x	x	
Sanitation	x	x	x	x	x						x	x	Nov-Mar (VA,NC), Mar-Jun (SC,GA,FL). Sanitation done during harvesting by removing overripen fruit, maybe some in the fall but not much, removing leaves
Insect And Mite Management	x	x	x	x	x	x				x	x	x	
Harvesting	x	x	x	x	x	x	x				x	x	Mar-Jul (VA,NC), Dec-May (NC-tunnel production), Mar-Jun (SC-high tunnel), Jan-May (GA-low tunnel), Nov-Apr (FL-high tunnel)

REFERENCES

Connelly, H., Paved, K., and Loeb, G. Landscape simplification decreases wild bee pollination services to strawberry. (2015) Landscape simplification decreases wild bee pollination services to strawberry. Agriculture, Ecosystems & Environment 211: 51-56.

MacInnis, G. and Forrest, J.R.K. (2019) Pollination by wild bees yields larger strawberries than pollination by honey bees. Journal of Applied Ecology.

Vob, A.C., Hauertmann, M., Laufer, M.C., Lach, A., Junker, R.R., and Eilers, E. (2023) Fungicides and strawberry pollination-Effects on floral scent, pollen attributes and bumble bee behavior. PLoS ONE 18(7): e0289283

Wietzke, A., Westphal, C., Gras, P., Kraft, M., Pfohl, K., Karlovsky, P., Pawelzik, E., Tscharntke, T., and Smith, I. (2018) Insect pollination as a key factor for strawberry physiology and marketable fruit quality. Agriculture, Ecosystems & Environment 258: 197-204.

Agehara, S. and Hochmuth, G. 2018. *Fertilization of strawberries in Florida* (CIR1141/CV003). University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024

Baggio, J. S., Marin, M. V., Mertely, J. C., and Peres, N. A. 2020. Chemical and cultivar trials to manage the new *Neopestalotiopsis* disease in Florida strawberry. *Berry/Vegetable Times*. University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024

Boyd NS, Reuss L. (2022). Survey of weed flora and weed management practices in Florida strawberry fields. *Weed Science*. 2022;70(3):353-360.

Brannen, P. M. (2024). 2024 Southeast Regional Strawberry Integrated Pest Management Guide Focused on Plasticulture Production (Annual Publication 119-5). University of Georgia Cooperative Extension.

City of Virginia Beach. 2020 Agricultural Fact Sheet: Strawberries.

Fair, B., Burrack, H., Fernandez, G., Hoffmann, M., Jennings, K., and Louws, F. 2018. *Crop profile for strawberries in North Carolina*. National IPM Database. Retrieved October 30, 2024

FDACS, Florida Department of Agriculture and Consumer Services. (2023). *F*lorida agriculture overview and statistics. Retrieved October 30, 2024.

Guan, Z., Wu, F., & Whidden, A. (2024). *Florida strawberry production costs and trends* (FE1013). University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024

Hernández-Martínez, N. R., Blanchard, C., Wells, D., & Salazar-Gutiérrez, M. R. (2023). Current state and future perspectives of commercial strawberry production: A review. *Scientia Horticulturae, 312*, 111893.

Hoffmann, M., Wrenn, A., Jackson, B., and Lewis, A. 2023. Strawberry greenhouse production in the Southeast: Soil-less substrate research in NC. *Southern Region Small Fruit Consortium*. Retrieved October 30, 2024

Kaur, Gagandeep and Lahiri, Sriyanka. 2023. *Chilli thrips, Scirtothrips dorsalis Hood (Thysanoptera: Thripidae) management practices for Florida strawberry crops* (ENY2076/IN1346). University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024

Lahiri, S.; Smith, H.A.; Gireesh, M.; Kaur, G.; Montemayor, J.D. (2022) Arthropod Pest Management in Strawberry. Insects, 13, 475.

Lopez Y., Olmo M.C. (2021). Strawberry Analysis 2021. The Outlook for Strawberry Production in Mexico.

Louws, F.J. 2018 Strawberry Diseases: Factsheets. https://strawberries.ces.ncsu.edu/strawberries-diseases

McWhirt, A., G. Fernandez, and M. Schroder-Moreno. 2015. Sustainable Practices for Plasticulture Strawberry Production in the Southeast. https://content.ces.ncsu.edu/sustainable-practices-for-plasticulture-strawberryproduction-in-the-southeast#

National Clean Plant Network. 2023. Berries. Retrieved October 30, 2024

North Carolina Agricultural Chemicals Manual. NCSU.

North Carolina State University. (2018). *Crop profile for strawberries in North Carolina*.

Samtani, J. B., Rom, C. R., Friedrich, H., Fennimore, S. A., Finn, C. E., Petran, A., Wallace, R. W., Pritts, M. P., Fernandez, G., Chase, C. A., Kubota, C., & Bergefurd, B. (n.d.). The status and future of the strawberry industry in the United States. Horttech. 29,1, 11-24

Shelton, A. (n.d.). *Biological Control: A Guide to Natural Enemies in North America*. Cornell University.

Strawberry Growers Information. Production. NC State Extension.

The Importance of Pesticides and Other Pest Management Practices in U.S. Strawberry Production. North Carolina Cooperative Extension Service.

U.S. Department of Agriculture, National Agricultural Statistics Service. (2022). *Nursery crops, 2020 summary*. USDA Economics, Statistics and Market Information System. Retrieved October 30, 2024.

U.S. Department of Agriculture, National Agricultural Statistics Service. (2022). *Quick Stats database.* Retrieved October 30, 2024

U.S. Department of Agriculture, National Agricultural Statistics Service. (2022). Noncitrus Fruits and Nuts 2021 Summary. USDA Economics, Statistics and Market Information System. Retrieved October 30, 2024, from

U.S. Department of Agriculture, National Agricultural Statistics Service. 2022. *2022 Census of Agriculture – Berries by Acres: 2022 and 2017* (Table 38). USDA. Retrieved October

30, 2024

U.S. Dept. of Agriculture/National Agricultural Statistics Service. 2023 State Agriculture Overview. National Agricultural Statistics Service. U.S. Dept. of Agriculture/National Agricultural Statistics Service.

U.S. Dept. of Agriculture/National Agricultural Statistics Service. 2023. Statistics by Subject. National Agricultural Statistics Service. U.S. Dept. of Agriculture/National Agricultural Statistics Service.

University of Florida, IPM Program. (2021). Revised Guidelines for Natural Enemies (Update: April 23, 2021).

USDA-NASS, U.S. Department of Agriculture, National Agricultural Statistics Service. (2024). Florida State Agriculture Overview. Retrieved October 30, 2024

Wade, T., Amon, K., Guan, Z., & Elwakil, W. (2024). *A review of strawberry production and price trends from 2010 to 2022* (FE1143). University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024

Whitaker, V. M., Peres, N. A., & Agehara, S. (2018). *'Florida Brilliance' strawberry* (HS1322). University of Florida Institute of Food and Agricultural Sciences. Retrieved October 30, 2024

ACKNOWLEDGMENTS

We gratefully acknowledge the input from state Extension Agents, Specialists, and growers from VA, NC, SC, GA, and FL in developing this document and the USDA and industry representatives who contributed to the workshop sessions. Thanks also go to Lynnae Jess, Roger Margarey, and Lacey Belanger for their support in putting together this document. The Southern IPM Center provided funding for developing this Pest Management Strategic Plan.

The National IPM Database is managed by the Southern Integrated Pest Management Center.

Funding for this project is provided by the USDA NIFA Crop Protection and Management Regional Coordination Program (Agreement No. 2018-70006-28884).

FLGANCSCVAStrawberryPMSP2024.pdf report generated 04-105-2025