

PEST MANAGEMENT STRATEGIC PLAN FOR STRAWBERRY PRODUCTION IN CALIFORNIA

TABLE OF CONTENTS

INTRODUCTION	5
Previous Pest Management Strategic Plan	5
Development of the New Plan.....	5
STRAWBERRY MARKET SHARE AND VALUE	10
STRAWBERRY PRODUCTION OVERVIEW	13
PEST MANAGEMENT FOR COMMERCIAL STRAWBERRY PLANTINGS	22
LAND PREPARATON THROUGH PLANTING	22
Activities Prior to Fumigation.....	22
Soil Fumigation	22
Planting	25
Work Group Recommendations for Pest Management From Land Preparation through Planting	25
PLANT ESTABLISHMENT (after Planting up to Root Establishment)	26
Work Group Recommendations for Pest Management in California Strawberries During Plant Establishment	27
VEGETATIVE GROWTH	28
Cultural and Worker Activities	28
INSECTS AND MITES	28
Work Group Recommendations for Insect and Mite Management in California Strawberries During Vegetative Growth	32
WEEDS	33
Work Group Recommendations for Weed Management in California Strawberries During Vegetative Growth	35
DISEASES	35
Work Group Recommendations for Disease Management in California Strawberries During Vegetative Growth	39
Nematodes	40
Work Group Recommendations for Nematode Management in California Strawberries During Vegetative Growth	40
VERTEBRATE PESTS	40
Work Group Recommendations for Vertebrate Control During Vegetative Growth.....	40
FRUIT DEVELOPMENT THROUGH HARVEST	41
Cultural and Worker Activities	41
INSECTS AND MITES	41

Work Group Recommendations for Insect Management in California Strawberries from Fruit Development through Harvest	45
WEEDS	45
Work Group Recommendations for Weed Management in California Strawberries from Fruit Development through Harvest	46
DISEASES	46
Work Group Recommendations for Disease Management in California Strawberries from Fruit Development through Harvest	48
VERTEBRATE PESTS	49
Work Group Recommendations for Vertebrate Control in California Strawberries from Fruit Development through Harvest	49
POSTHARVEST	49
DISEASES	49
INSECTS	50
Work Group Recommendations for Postharvest Insect and Disease Management	50
STRAWBERRY INDUSTRY CONCERNS	51
Labor and influence on Pest Management	51
New Products	51
Regulatory Restrictions	52
IR-4 System Project Priorities	54
International Trade/CODEX	54
Work Group Recommendations for International Trade/Codex Concerns	54
Consumer Perception	54
Worker Protection	55
Work Group Recommendations for Worker Protection	55
Food Safety	55
Work Group Recommendations for Food Safety	56
Impact of Weather, Drought, and Irrigation	56
CRITICAL ISSUES FOR THE CALIFORNIA STRAWBERRY INDUSTRY	58
REFERENCES AND RESOURCES	60
APPENDICES	64
1. Land Preparation, Cultural Practices, Pest Management Activities and Nursery Planting and Harvesting in California	64
a. Oxnard Production Region	64
b. Santa Marial Production Region	64

c. Watsonville/Salinas Production Region.....	64
2A. Description of Cultural Practices, 2016	64
2b. Description of Pest Management Activities, 2016.....	64
3. Seasonal Pest Occurance in California Strawberries	64
a. Orange County/San Diego Production Region.....	64
b. Oxnard Production Region	64
c. santa Maria Production Region.....	64
D. Watsonville Production Region	64
4. Efficacy of Insect Management Tools Used in California Strawberries	64
A. Primary Insects – Registered and un-registered Chemical Products.....	64
2a. Primary Insects – Non-chemical Management Tools.....	64
B. Secondary Insects – REgistered and Un-Registered Chemical Products	64
2b. Secondary Insects – Non-Chemical Management Tools.....	64
5. Relative Toxicity of Insect Management Tools to Beneficial Organisms in California Strawberries	64
6. Efficacy of weed Management tools Used in California Strawberries	65
7. Efficacy of Disease management tools Used inCalifornia Strawberries	65
8. Efficacy of Vertibrate Pest Management Tools Used In California Strawberries.....	65
9. Chemical Use on California Strawberries 2013-2016	65
10. Maximum Residue Levels For Strawberries	65
11. Members of the California Strawberry Work Group	65

INTRODUCTION

PREVIOUS PEST MANAGEMENT STRATEGIC PLAN

The Pest Management Strategic Plan (PMSP) is a document developed by growers, researchers and industry partners to address pest management needs and priorities for California strawberries.

The plan is intended to assist growers with their pest management practices, while serving as a roadmap to the future strategies by identifying priorities for research, regulatory activity (including registration of new active ingredients or products), and education/training programs.

This plan is an update to the 2003 PMSP for Strawberry Production in California. The foundation documents for the 2003 PMSP were the Integrated Pest Management for Strawberries, 1994 (UC Publication 3351), and the Crop Profile for California Strawberries, October 1999. The original workgroup met during 2002.

DEVELOPMENT OF THE NEW PLAN

The new PMSP was created in consultation with a new set of stakeholders to address the industries' current landscape. The plan was developed through a series of industry working group meetings held in Watsonville, Santa Maria and Oxnard in July 2016; and then further consultation and input was obtained from experts at the Cal Poly Strawberry Center and University of California throughout 2017-18. In addition, data has been taken from the UC IPM manual and the Strawberry Production Manual.

Notably, many events have changed the landscape for strawberry production in California since the 2003 PMSP. The loss of the fumigant methyl bromide for strawberry fruit production due to the Montreal Protocol Treaty on Substances That Deplete the Ozone Layer (<https://ozone.unep.org/>; EPA 2015), the development of pest resistance to many of the chemistries important to pest management in strawberries, an ever-changing regulatory environment, and the increase in organic strawberry production, among other factors that create new challenges for growers and processors will be addressed in this Plan update. New avenues of research have opened up and must be pursued. New chemical and non-chemical pest management strategies must be developed. At the same time, education and communication within the industry and between the industry, researchers, pesticide registrants, regulators and the public have become more critical than ever to providing safe, abundant and affordable strawberries to the consumer and success for the strawberry producer.

SINCE THE 2003 PMSP, THE CALIFORNIA STRAWBERRY INDUSTRY HAS INCREASED THE NUMBER OF ACRES, REACHING A PEAK IN 2014 AT 41,500 ACRES. SINCE 2014 HOWEVER, ACREAGE CONTINUES TO DECLINE WHILE PRODUCTION REMAINS STABLE BECAUSE OF THE AVAILABILITY OF HIGH-YIELDING CULTIVARS.

EXECUTIVE SUMMARY

As a result of the working group meetings held in Watsonville, Santa Maria and Oxnard in July 2016 and additional input provided in 2018, the PMSP working group identified the following research, regulatory, and educational priorities to maintain the vitality of the strawberry industry in California.

Research

The need for production research will continue to be a priority in order to implement a successful PMSP. With the total phase-out of methyl bromide, finding effective fumigant and non-fumigant strategies to combat soilborne diseases and weeds remains a critical concern for strawberry growers. New methods to produce clean nursery stock need to be explored. Knowledge of soil microbiology must be expanded, and new chemical and biological control agents evaluated. Increasing resistance to existing materials heightens the need for development of new products and techniques for managing lygus, mites, whiteflies, diseases and weeds. Increased interest in organic production has led to new challenges for researchers.

RESEARCH	• Continue research on alternative and effective fumigants, emission reduction, and non-fumigant chemical strategies to combat soilborne diseases • Develop new cultivars which are resistant to insects, nematodes, and diseases • Identify genetic resistance for key strawberry diseases, and incorporate resistance into new cultivars • Develop new methods of producing clean nursery stock that is disease, virus, and insect-free • Evaluate new materials and techniques to manage insects and arthropods • Research on improved use of predators • Evaluate new chemical controls for lygus • Evaluate cutworm controls • Collect quantifiable pest and damage data to support Section 18 applications during emergency pest events • Develop a resistance management strategy for lygus and spider mites • Evaluate new materials for in-season and harvest-time whitefly control • Develop and evaluate herbicides for use under plastic mulches and in furrows • Determine fungicide resistance in powdery mildew populations • Conduct research on the biology and epidemiology and control of anthracnose • Conduct research on effective cultural practices and materials to combat soilborne diseases • Evaluate new chemical and biological control agents for key plant and fruit diseases including powdery mildew, gray mold and anthracnose • Develop a strategy for fungicide use in nurseries and fruit production fields that reduces selection pressure and maximizes efficacy for both environments • Research post-plant options for nematode control and their efficacy
-----------------	--

	• Develop information on soil microbiome and microbiology to determine epidemiology of soilborne diseases • Develop and evaluate new herbicides that can be injected through the drip system during the winter to combat invasive weeds • Conduct research on alternative weed management strategies • Develop weed management options and techniques for use in organic systems (e.g., ASD, steam, solarization, etc.) • Evaluate cultural methods to manage weeds in buffer areas (e.g., anaerobic soil disinfestation, steam and other non-fumigant alternatives) to allow growers to crop these areas with strawberry • Develop improved pest management and crop production methodologies for organic growers • Conduct research on improvement of strawberry cultivars through breeding to improve horticultural and pest resistance for organic and conventional production systems • Conduct research on pest management in benchtop/greenhouse production • Conduct research in labor-saving automation • Develop pest management programs that incorporate nurseries and fruit grower practices to improve efficacy and reduce resistance development
--	--

Regulatory

Methyl Bromide is no longer available for use for preplant fumigation for the production of any crop in the United States, although it can still be used under a Quarantine and Pre-Shipment Exemption for the production of strawberry nursery plants. It is critical for the strawberry industry that this exemption and use be maintained so that growers can start out with clean plants as both organic and non-organic producers must have access to clean nursery stock. Maintaining registration of remaining fumigants' 1,3-dichloropropene (1,3-D), chloropicrin and the methyl isothiocyanate (MITC) generators and the registration of new alternative fumigants is a priority for California growers. In addition, the development of resistance to existing chemistries exhibited in insect, mite, disease and weed populations, is reducing the effectiveness of products registered for strawberries and reducing the pest management tools available to control many key pests. The need for the registration of new modes of action that can be integrated into new resistance management strategies for strawberry pests is critical. As regulatory requirements become more complex, on both a local and international level, there is a need to encourage as much harmony and consistency as possible among counties, states and countries.

REGULATORY	• Protect existing chemistries • Correct misinformation on pollinators which regulators use to make decisions • Work with DPR as it develops alternative label amendments and eliminates township caps for 1,3-D • Retain methyl bromide for nursery production (even organic production requires fumigated nursery stock) • Register effective materials that are alternatives for methyl bromide (e.g., allyl isothiocyanate or Dominus®) • Register new products for key insect and arthropod pests • Register more than one fungicide or new material at a time for resistance management • Work with regulators to attempt to obtain multiple Section 18s of different chemistries for resistance management • Seek PHIs of a maximum of 3 days for in-season applications • Register materials for lygus, whiteflies, thrips and powdery mildew • Seek Section 18 for Methomyl crop destruct application for lygus • Register new herbicide chemistries and modes of action with effective weed control and where possible PHI of 3 days or less • Reduce the size of current buffer zone requirements • Re-evaluate fumigant modeling that influences CA regulations • Maintain activity in IR-4 and an active pipeline of product registrations for disease, insect/arthropods, nematodes, and weeds • Encourage consistent interpretation of label requirements and regulations by County Ag Commissioners • Reduce Carbaryl bait PHI • Encourage as much uniformity as possible in county permit requirements • Harmonize CalEPA and US EPA registrations to speed up new product registrations • Harmonize international tolerances and MRLs, particularly for new products • Protect existing MRLs (and MRL deferrals) as countries move away from Codex and to their own national lists • Identify potential trade irritants as early as possible in the research and registration process; insure there are no conflicts with provisions of the US-Mexico-Canada Agreement or Codex MRL lists • Ensure access to a stable and reliable labor supply
------------	---

Education

The industry should seek avenues to educate the public about the precautions taken and the benefits derived from fumigation and other practices employed in strawberry production. There is a need within the industry among growers and PCAs to emphasize the techniques and importance of resistance management strategies. There is also a need to increase the coordination between strawberry nursery growers and fruit producers with respect to resistance management for the active ingredients they both utilize. Educational materials of all types should be available in all of the languages spoken by the diverse population of strawberry growers and workers.

EDUCATION	• Educate the public about fumigation safeguards and benefits • Provide resistance management training for PCAs and growers • Educate regulators about resistance management and the need for multiple modes of action • Educate regulators regarding pests for which resistance management strategies are critical and on any strategies that have been developed • Educate regulators about the absence of deliberately placed pollinators in strawberry production • Educate regulators on system approaches to using fumigants • Educate growers and PCAs on fumigant alternatives • Educate the public and regulators on the need for fungicides • Educate growers, PCAs and commodity members on the use of best management practices (BMPs) to protect and improve water and soil quality • Work with nurseries to provide information and communication regarding plant quality and feedback from growers • Develop educational materials targeted to minority growers (e.g., Spanish, Mixtec, Hmong, etc.) • Continue educational activities with growers and the public about production challenges facing the strawberry industry • Collaborate with the California Association of Pest Control Advisors (CAPCA) and other organizations in educating growers and the public • Educate registrants that new herbicides should have a PHI of 3 days or less Educate regulators about strawberry growing practices and pest management issues
-----------	---

STRAWBERRY MARKET SHARE AND VALUE

California is the nation's leading producer of strawberries as the state produced 86%¹ of the country's total fresh and 98%² of frozen strawberries in 2017. Statewide strawberry production averages over 76,500 pounds per acre each season (California Department of Food and Agriculture [CDFA], 2018a). California (2017) strawberries are valued at \$3,100,215,000 and rank 4th among the highest valued commodities across the state.

Table 1. California Strawberry Production Statistics for Fresh Market and Processing Fruit in the United States.

	U.S. Rank (#)	CA Share of U.S. Prod. (%)	Area Harvested (1000 Acres)	Short Tons (2,000 Lbs.) (1000 Tons)	Total Value (\$1,000)	Leading Producing Counties (percent of gross value)
Fresh Market	1	86.0*	38.2	1,189.4	2,925,863	Monterey, Ventura, Santa Barbara, San Luis Obispo, Sacramento
Processing	1	98.0 [^]	–	270.3	174,352	Ventura, Santa Barbara, Others
All	1	88.9	38.2	1,461.2	3,100,215	Monterey (30.0%), Ventura (28.6%), Santa Barbara (20.0%), San Luis Obispo (10.0%), Santa Cruz (9.2%)

	U.S. Rank (#)	CA Share of U.S. Prod. (%)	Area Harvested (1000 Acres)	Production (1000 Tons)	Total Value (\$1,000)	Leading Producing Counties (percent of gross value)
All	1	88.9	38.2	1,461.2	3,100,215	Monterey (30.0%), Ventura (28.6%) Santa Barbara (20.0%), San Luis Obispo (10.0%), Santa Cruz (9.2%)

Approximately 81.4% of strawberries harvested are for the fresh market, while 18.5% is frozen for the processed market.

¹ Share calculated based on [CSC District Reports](#)

² Processing Strawberry Advisory Board, 2018 Annual Report

Table 2. California Strawberry Acreage, Production (Fresh Market and Processing) and Value, 2005-2017 (CDFA, 2018a).

Crop Year	All		Fresh Market			Processing			All		
	Harvested	Yield Per Acre	Production	Value Per Unit	Total Value	Production	Value Per Unit	Total Value	Production	Value Per Unit	Total Value
	Acres	Cwt	Cwt	\$/Cwt	\$1,000	Cwt	\$/Cwt	\$1,000	Cwt	\$/Cwt	\$1,000
2005	34,300	600	15,825,000	62.60	990,645	4,755,000	27.80	132,189	20,580,000	54.60	1,122,834
2006	35,800	590	16,542,000	65.10	1,076,884	4,621,000	26.50	122,457	21,163,000	56.70	1,199,341
2007	35,500	605	17,159,000	75.70	1,298,936	4,381,000	25.50	111,716	21,540,000	65.50	1,410,652
2008	37,600	605	18,605,000	77.30	1,438,167	4,070,000	34.40	140,008	22,675,000	69.60	1,578,175
2009	39,800	625	20,040,000	79.00	1,583,160	4,816,000	29.50	142,072	24,856,000	69.40	1,725,232
2010	38,600	670	20,851,000	80.30	1,674,335	5,008,000	27.80	139,222	25,859,000	70.10	1,813,557
2011	38,000	680	20,462,000	86.10	1,761,778	5,384,000	33.80	181,979	25,846,000	75.20	1,943,757
2012	39,000	710	21,936,000	88.80	1,947,917	5,710,000	32.00	182,720	27,646,000	77.10	2,130,637
2013	41,500	665	22,398,000	90.40	2,024,779	5,175,000	34.00	175,950	27,573,000	79.80	2,200,729
2014	41,500	665	22,100,000	100.00	2,210,000	5,492,000	41.50	227,918	27,592,000	88.40	2,437,918
2015	40,500	685	21,600,000	73.90	1,596,240	6,097,000	45.80	279,243	27,697,000	67.70	1,875,483
2016	38,200	760	22,761,100	123.00	2,799,615	6,212,800	45.90	285,169	29,032,000	106.00	3,084,784
2017	38,200	765	23,787,500	123.00	2,925,863	5,406,300	32.20	174,352	29,223,000	106.00	3,100,215

Yield

Over the past 15 years, cultivars have been released from both public and private breeding programs that produce greater yield. From 2016 to 2018, yields (lb/acre) have increased almost 20% due to this shift by growers to plant higher-yielding cultivars, despite reductions in acreage.

Exports

In 2017, California exported 259.5 million pounds of fresh strawberries and 43.2 million pounds of frozen strawberries, with a combined value of \$424 million. California fresh strawberry exports represented 14.0 percent of the state's fresh production and 10.9 percent of frozen production (California Strawberry Commission [CSC], 2019a).

California strawberries represent the state's 10th most valuable agricultural product exported. Further, California strawberries accounted for 87.9 percent of the nation's strawberry exports (CDFA, 2018b). Major destinations for California strawberry exports are listed below (Table 3A and 3B). It is also important to note that beginning in 2016, California strawberries gained market access to China. Since gaining market access, 104,905 fresh lbs. were exported in 2017 with a value of \$245,000 (CDFA, 2018b).

Table 3A. California Fresh Exports to the Top Three Export Countries.

Amount Exported (lb x 1,000)					
Destination (Country)	2013	2014	2015	2016	2017
Canada	212,057	183,114	176,832	184,131	182,300
Mexico	30,239	39,954	40,430	35,451	45,963
Japan	7,413	7,169	6,404	6,190	6,434
Total (lb x 1,000)	268,608	250,882	242,179	250,548	259,526
Value (USD) (x 1,000)	\$377,019	\$384,100	\$365,498	\$378,145	\$383,497

Table 3B. California Frozen Exports to the Top Three Countries.

Amount Exported (lb x 1,000)					
Destination (Country)	2013	2014	2015	2016	2017
Canada	25,734	26,426	12,169	17,974	13,633
Mexico	10,369	7,110	5,645	6,323	4,616
Japan	12,634	11,423	9,495	7,480	7,173
Total (lb x 1,000)	58,920	55,928	41,472	46,265	43,171
Value (USD) (x 1,000)	\$49,101	\$45,745	\$35,701	\$36,044	\$40,480

Market Share and Value Summary

- California produces 86% of the country's total fresh and 98% of frozen strawberries
- 81.4% of strawberries are for fresh market, while 18.5% are frozen for the processed market
- Statewide strawberry production averages 76,500 pounds per acre each season
- In California, strawberries ranked as the 4th most valuable agricultural commodity; 3rd most valuable crop
- California strawberries represent the state's 10th most valuable agricultural product exported

STRAWBERRY PRODUCTION OVERVIEW

Availability

California strawberries are available year-round. In winter, strawberries ship from Southern California and production moves to the northern districts with the warming spring temperatures. Volume peaks in April, May and June when production in all districts overlaps and an average of six to seven million trays per week are harvested. After July 1, about 50% of the crop is harvested (CSC, 2019b).

Use of Certified Nursery Stock

Healthy planting stock is vital to producing high quality strawberries; however, plant growers and fruit growers are separate groups. Therefore, this PMSP will not address the strawberry nursery industry in California. However, working group members did express a desire to address needs of the nursery industry and to coordinate with the industry, particularly with respect to resistance management and ensuring delivery of clean nursery stock to fruit growers.

Land

Most strawberries are planted on land that is leased and in rotation with producers of leafy green and/or cole crops. The leafy greens and cole crop industries have benefited from rotation with strawberries due to the frequent practice of pre-plant fumigation which provides residual benefit of disease, weed, and nematode control for crops grown following strawberries.

Planting

California strawberry plants are first grown in outdoor field nurseries, then transplanted annually into fruit grower's fields in raised beds. Clean nursery stock that is disease- and insect-free is essential to ensure the success of the transplants once planted in the field. The beds are covered with plastic mulch to keep the berries away from the soil, reduce weeds, and help conserve water. Drip irrigation reduces disease problems by keeping moisture away from the fruit while using water more efficiently.

All California strawberry cultivars are self-fertile; the flowers are monecious which means they possess both male (stamens) and female (pistils) parts. Bees are not required for pollination, and growers do not bring in hives to enhance pollination and fruit development. The time from flower development to ripe fruiting takes 25 to 30 days depending on cultivar and temperature (Table 4).

Table 4. Developmental Time and Phenology for Strawberry Plants and Fruit Development in California.

Root and Vegetative Development for Stand Establishment	Flowering	Fruit Development	Harvest Period
15 to 30 days after transplanting	~15 days after planting; however early bloom is removed to encourage vegetative growth Begins 30 to 60 days after transplanting	25 to 30 days from flower to fruit	Begins 4 months after fall planting (2 months for summer planting) and lasts 3 to 7 months depending on cultivar, location and market conditions

High Plastic Tunnels

Nearly all California strawberries are grown in open fields on raised beds covered with plastic mulch and irrigated through drip irrigation tape. High plastic tunnels are sometimes employed to shield plants from rain, wind and harsh sunlight, to exclude birds, to prevent dew formation and moderate temperatures (e.g., warmer inside when cooler outer temperatures exist). Plastic tunnels are generally 12 feet high and 27 feet wide depending on bed spacing. The plastic is lashed to a metal frame using ropes. Beneath the plastic tunnels, strawberries are grown in regular raised beds in soil or on “tabletops” using substrates such as peat moss and coconut fiber placed in small troughs, suspended on metal posts about 3 feet above the soil surface. Tabletop production is common in Europe but has not been widely practiced in California due to nearly ideal outdoor weather conditions and the cost of materials and labor required. Tabletop production offers the advantages of elimination of soilborne pathogens and improved working conditions for harvesters who can pick fruit in an upright position. Combined, both of these systems under high plastic tunnels are employed on approximately 500 acres statewide.

Harvesting

Once ready for harvest, all California strawberries are hand-picked to ensure only the highest quality berries are selected with minimal handling. Hand harvesting provides an opportunity for human eyes and hands to visit each plant throughout production; this in turn ensures early detection of pest infestations or disease outbreaks before widespread pesticide applications become necessary. Strawberry plants continually produce new fruit throughout the growing season, and during peak season, plants are harvested every three days.

Postharvest and Shipping

Within two hours of harvest, fruit are transferred to a cooling facility where forced-air cooling draws out field heat, preserving optimum fruit quality and firmness. When cooled, the strawberries are loaded onto refrigerated trucks for same-day shipment. Keeping the fruit at 32°F during transport extends shelf life and maintains a quality product for consumers domestically and internationally. Most fruit destined for distant markets (eastern US and export) are treated using controlled atmosphere during cold storage. Once the palletized fruit reach 32°F, the entire pallet of fruit is bagged, the ambient air is removed, and a proprietary mixture of gasses is injected into the bag. This treatment will add 1-2 days to fruit shelf life.

Growing Regions

Strawberries are grown within five distinct areas of California: Watsonville/Salinas, Santa Maria, Oxnard, Orange County/San Diego, and the Central Valley (CSC, 2018).

Strawberry production starts in the southern part of the state and works its way up the coast. Farms in Orange County/San Diego and Oxnard harvest fruit from January to May. Farms in Santa Maria and Watsonville/Salinas harvest from March through November. In the Central Valley, the summer planting produces fruit that is harvested from April – July. A fall crop is then harvested from July – October. Oxnard and Santa Maria plant a summer crop which is harvested from September to December. Together, these growing regions



and cropping cycles allow California strawberries to be available year-round (see Appendix 1).

Strawberries are grown in a wide range of soil types, from sand to clay loams, but sandier soils are preferred because of drainage properties and their ability to form uniform beds. Strawberries perform best in areas with daytime temperatures in the 70s and nighttime temperatures in the 50s. Freezing temperatures will kill blooms and disrupt fruit production while temperatures above 80°F will make fruit soft and more susceptible to bruising during harvest and postharvest handling.

Table 5. Characteristics of the Major Strawberry Fruit Production Areas in California for a Typical Season (CSC, 2019c).

	Orange County/ San Diego	Oxnard	Santa Maria	Watsonville/Salinas
Transplanting	Sep-Oct	Mid-Sep - Oct	Oct-Nov	Oct-Nov
Harvest Period	Jan-May	Jan – Jun (75.7%) Sep – Dec (24.3%)	Mar-Nov	Apr-Nov
Main Cultivars (% is based on 2019 reported and estimated acreage) Fall Planted	'San Andreas' (45.2%) 'Fronteras' (40.7%)	Proprietary cultivars (57.4%) 'Fronteras' (20%) 'San Andreas' (14.7%)	'Monterey' (43.7%) 'San Andreas' (22.8%) Proprietary cultivars (17.3%)	Proprietary cultivars (49.7%) 'Monterey' (39.7%) 'Cabrillo' (6.3%)
Summer Planted	None	Proprietary cultivars (86.4%) 'Portola' (13.4%)	'Portola' (55.3%) Proprietary cultivars (26.3%)	None
Acreage: Fall Planted Acreage for Winter, Spring, and Summer Production	221 (0 organic)	5,300 (190 organic)	8,583 (911 organic)	11,601 (2,011 organic)
Acreage: Summer Planted Acreage for Fall Production	None	3,462 (292 organic)	2,528 (745 organic)	21 (21 organic)
Trays (as reported in 2018)	725,782	37,900,061	70,366,558	115,499,064
Key Pests Tier I	Lygus bug Twospotted spider mites	Lygus bug Twospotted spider mites	Lygus bug Twospotted spider mites	Lygus bug Twospotted spider mites
Key Pests Tier II	Aphids Cyclamen mite Caterpillars Lewis mite Spotted wing drosophila Thrips Whiteflies	Aphids Cyclamen mite Caterpillars Lewis mite Spotted wing drosophila Thrips Whiteflies	Aphids Cyclamen mite Caterpillars Lewis mite Spotted wing drosophila Thrips Whiteflies	Aphids Cyclamen mite Caterpillars Lewis mite Spotted wing drosophila Thrips Whiteflies
Key Foliar and Fruit Diseases	Botrytis Powdery Mildew	Powdery Mildew Botrytis	Powdery Mildew Botrytis	Powdery Mildew Botrytis
Key Soilborne Diseases	Verticillium Wilt Fusarium Wilt Macrophomina Crown Rot	Macrophomina Crown Rot Fusarium Wilt	Macrophomina Crown Rot	Fusarium Wilt Verticillium Wilt Macrophomina Crown Rot

Strawberry Cultivars in California

California has several strawberry cultivars in commercial production, each with its own characteristics, advantages and harvest window. Public cultivars released by the University of California make up 58.9% of the total state acreage. Proprietary cultivars make up 40% of acreage, 0.2% of the acreage is planted with public cultivars from the University of Florida, and the remaining 0.9% of acreage is from other publicly available cultivars. The following represents top cultivars in both fall- and summer-planted production systems.

'Albion': This day-neutral cultivar produces consistent yield over the growing season, superior flavor and good weather tolerance. 'Albion' generally has a slightly lower spring peak and is less prone to a summer gap in production than other cultivars. 'Albion's' characteristics include large, conical, firm and very sweet berries, with a bright red sheen and long shelf life. 'Albion' is planted on 0.7% of the state's acreage and 1.7% of the organic acreage.

'Monterey': A day-neutral cultivar, with a similar production pattern to 'Albion'. The fruit for 'Monterey' is slightly larger but less firm than for 'Albion'. Postharvest traits for 'Monterey' are like those for 'Albion'. 'Monterey' has outstanding flavor with a distinct sweet aftertaste that is unique among California cultivars. 'Monterey' accounts for 38.8% of the state's acreage, and 18.1% of the organic acreage. It is also occasionally used for summer planting.

'San Andreas': A moderate day-neutral cultivar with a production pattern very similar to 'Albion'. The fruit is exceptional in appearance; color is slightly lighter than 'Albion'. This cultivar has a good disease resistance profile. High quality, large fruit early in the season, together with a low chilling requirement, make this a suitable cultivar for southern California. This cultivar accounts for 11.9% of the state's acreage and 6.1% of the organic acreage.

'Portola': This strong day-neutral cultivar is especially well adapted to spring and summer planting. Similar in size to 'Albion', the fruit is lighter in color and somewhat glossy. Postharvest characteristics are like those for 'Albion'. Fruit flavor is generally less desirable than 'Albion' or 'Monterey', but yield is higher and especially consistent throughout the fruiting season. Portola is planted on 10.4% of the state's acreage and 10.1% of the organic acreage. It is the primary public cultivar used for summer planting (54.3%).

Proprietary Cultivars: Many farms in California grow proprietary cultivars. Unlike the publicly available cultivars bred by the University of California, proprietary cultivars are grown primarily for, and bred by individual, private companies. Proprietary cultivars represent 40.2% of the state's acreage, and 56.1% of the organic acreage.

Organic Trends: In 2019, all major reported cultivars are expected to be included in the state's organic acreage. Proprietary cultivars dominate the mix, totaling 56.1% of the state's organic acreage. 'Monterey' accounts for 18.1% of the acreage, while 'Portola' accounts for 10.1%. Other cultivars include: 'San Andreas', 6.1%; 'Sweet Ann', 4.1%; and 'Fronteras', 3.2%.

Organic acreage has increased in the last 10 years; however, a barrier for growers switching to organic production is the required three-year transition period. Growers discussed how the marketplace does not support the risk it takes to grow organic, particularly the increased cost for nutrients, and less effective materials for pest and disease management. In addition, yields in organic production systems are typically 25% less than in conventional systems (de Ponti et al.,

2012). Some growers are experimenting with different substrate (soilless) systems (see tabletop system described on page 14) as a means of avoiding soilborne disease. Currently (2018), the National Organic Standards Board allows for soilless growing medium (substrate) as an approved method of organic production. Additional research is needed for organic production systems, particularly for pests and diseases associated with yield reductions.

Pests and diseases of most concern to California strawberry growers are listed in Table 6 below.

Table 6. Major Strawberry Pests in California.

Pests and Diseases	Concern
Insects and Arthropod Pests	
Twospotted Spider Mite (<i>Tetranychus urticae</i>)	Serious pest in all California growing areas
Lygus Bugs (<i>Lygus hesperus</i>)	Serious pest in all California growing areas, feeding on seeds causes deformed or "cat-faced damage", i.e., distorted fruit, rendering it unsaleable.
Greenhouse Whitefly (<i>Trialeurodes vaporariorum</i>)	Periodically a serious pest in Oxnard, South Coast, and parts of Central Coast, primarily where there are overlapping annual plantings or second year plantings; has the potential to transmit viruses.
Cyclamen Mite (<i>Steneotarsonemus pallidus</i>)	Important pest of Central Coast; infestations can often be traced back to infested nursery transplants.
Strawberry Aphid (<i>Chaetosiphon fragaefolii</i>)	Aphids damage fruit in all growing regions, and occasionally cause yield losses because their honeydew deposits on fruit cause sooty molds, and skins shed by aphid nymphs stick to fruit; aphids also transmit viruses that can cause significant economic losses. Aphid control is crucial in nurseries.
Melon Aphid or Cotton Aphid (<i>Aphis gossypii</i>)	
Green Peach Aphid (<i>Myzus persicae</i>)	
Potato Aphid (<i>Macrosiphum euphorbiae</i>)	
Western Flower Thrips (<i>Frankliniella occidentalis</i>)	Primary concern is fruit bronzing, which can render fruit unsaleable.
Black Cutworm (<i>Agrotis ipsilon</i>) Roughskinned Cutworm (<i>Athetis mindara</i>)	Occasionally damages plant crowns but can also feed on fruit; primarily of concern in the Central Coast growing region.
Beet Armyworm (<i>Spodoptera exigua</i>)	Occasionally causes serious crown and fruit damage to summer- and fall-planted strawberries in southern production areas.
Light Brown Apple Moth (<i>Epiphyas postvittana</i>)	Pest of concern because of quarantine regulations that restrict its presence on harvested berries being shipped from designated quarantine areas. It is primarily a leaf feeder when found in strawberry fields, only rarely feeds on fruit.
Corn Earworm, aka Tomato Fruitworm; Cotton Bollworm (<i>Helicoverpa zea</i>)	Corn earworms are a significant problem in the South Coastal Region but can be found elsewhere: larvae cause direct damage to fruit.
Garden Tortrix (<i>Ptycholoma [Clepsis] peritana</i>)	Contamination of South Coast fields before fruit is sent to the processors during late June and July can be a serious problem.

Vinegar Fly (Fruit Fly; <i>Drosophila melanogaster</i>, <i>Drosophila suzukii</i> and others)	Primarily a problem in strawberries picked for processing, usually from the Oxnard Plain south; <i>Drosophila suzukii</i> larvae occasionally cause direct damage to ripe fruit.
Diseases	
Botrytis Fruit Rot (Gray Mold; <i>Botrytis cinerea</i>)	Most common and most important fruit disease of strawberry. Can cause losses of 30 to 40% in areas if growers do not spray during wet weather or do not have effective materials (i.e., organic production or fungicide resistance). Losses can reach 50% to 60% during long periods of cool, wet weather; when disease in the field reaches this level, harvest is abandoned, and the economic loss is 100%.
Verticillium Wilt (<i>Verticillium dahliae</i>)	Increasingly important throughout all production areas. Disease is slow growing, but once established, extremely difficult to manage. Disease can spread from contaminated plantings by movement of infested soil; control at nursery stage is crucial.
Anthracnose Fruit and Root Rot (<i>Colletotrichum acutatum</i>)	Increasingly important disease of fruit and roots. Appears to come on infected transplants from nurseries and can lead to plant establishment problems in the early season and fruit rot during rainy/foggy weather.
Rhizopus Fruit Rot (<i>Rhizopus</i> spp.)	After elevated temperatures, can be quite destructive; has caused 20% to 35% yield loss in the Oxnard production area.
Angular Leaf Spot (<i>Xanthomonas fragariae</i>)	Impacts from this disease are increasing; a severe problem in all nursery locations and becoming a greater problem in the Central Coast and South Coast regions. Wet weather promotes the development and spread of the disease.
Foliar Nematode (<i>Aphelenchoides fragariae</i>)	Control based on utilizing certified pest- and disease-free nursery stock grown in soil treated with methyl bromide/chloropicrin; generally, not a problem, but may become a problem with the loss of methyl bromide, or other soil fumigants.
Root Knot Nematode (<i>Meloidogyne hapla</i>)	

Pesticide Use in California Strawberries

Pesticides are used in both conventional and organic production to manage damage caused by pests. California strawberry farmers abide by safe farming practices in strict compliance with federal (Environmental Protection Agency; EPA), state (Department of Pesticide Regulation; DPR), and county agricultural commissioner (CAC) regulations, permit requirements, and controls. All applications of pesticides in California are made under the control of the growers, their licensed Pest Control Advisors (PCAs), and/or their Pest Control Operators (PCOs). Only registered pesticide products are used, and they are applied in compliance with all state and federal laws, rules, and regulations, and all label recommendations.

Growers, PCAs, and PCOs maintain communication during planting and production periods through frequent field visits by grower representatives and/or their PCAs. Before any application, the applicator must inform all parties (e.g., harvesting crews, weeding crews, irrigators, etc.) near the area to be treated of the intent to apply pesticides, and must also post notices around fields and file post-application paperwork with the appropriate state and/or federal agency.

Many of the pesticides upon which growers have historically relied have lost effectiveness due to pest resistance. Regulatory actions at the federal, state and county levels have limited or eliminated the use of other key materials. More in-depth discussion of the challenges presented by the loss of critical chemistries will be found in the sections of the Plan covering the key pests affected.

Worker Activities

Strawberry yield and quality depend upon the growers' practices, and most growers retain experts in various areas (e.g., irrigation, nutrition, pest control, etc.) to manage their crop to its maximum potential. Specific worker activities involved in managing a strawberry crop include: cultural activities (transplanting, mulching, preparing beds, cultivating, irrigating, pruning, thinning, applying fertilizer, harvesting, and analyzing soil/water/plant tissue for nutrient content), and pest management activities (monitoring fields throughout the entire year; scouting for insect, disease, weed, and nematode pests; fumigating; applying pesticides; vacuuming; hand weeding; and releasing beneficial organisms). Specifics of worker activities and timelines for common production and pest management activities in California strawberries are provided in Appendices 2 through 4.

Organic Production

While producing organic strawberries in California is challenging, 12.6 percent of California's strawberry acreage (4,278 acres in 2017) is dedicated to organic strawberries -- more than any other place in the world. The most successful organic acreage is planted in areas with little or no history of soilborne disease (like *Verticillium* wilt, *Fusarium* wilt and/or *Macrophomina* crown rot) and other components of the strawberry pest complex. Organic production produces significantly lower yields than conventional production, with yields on average, 28% less than yields achieved with conventional culture using soil fumigation (López-Aranda et al., 2001). In addition, weed growth resulted in very high hand-weeding costs (37% higher than in conventional production; Klonsky, 2011).

While organic production research continues, root diseases take the heaviest toll on organic strawberries. Before the advent of soil fumigation in the late 1950s, even with improved university cultivars, average strawberry yields were approximately 5,000 lb/acre (Geisseler and Horwath, 2011). Today, the average yield is 46,000 lb/acre – down from the almost 50,000 lb/acre achieved when methyl bromide was used for soil fumigation. This striking comparison demonstrates the need for fumigant alternatives, including practices which would be incorporated in organic production. Several alternatives have been the subject of intense research over the last 15 years (López-Aranda et al. 2001). These include anaerobic soil disinfestation, steam, solarization, cover cropping and host plant resistance.

Anaerobic Soil Disinfestation. Anaerobic soil disinfestation (ASD) is a method to treat soilborne diseases and insects through the temporary elimination of oxygen in the soil. In this method, a carbon source is incorporated into the soil, water is added to fill the pore space in the soil, and then the soil is covered with a plastic mulch while anaerobic conditions are formed by microbes in the soil. This results in significant reduction of some soilborne diseases (Shennan et al., 2018), but not all. *Fusarium* wilt has been shown to increase when ASD is applied in the cool, Central Coast areas where it is present in strawberry production fields (Mazzola et al., 2018). Therefore, it is important that growers identify what soilborne diseases are present in their fields before implementing ASD techniques.

Soil Solarization. Solarization of the soil has been successfully used in other production systems to eliminate pathogens and insect pests. In this method, clear plastic is stretched tightly over the soil surface to allow sunlight and heat (solar radiation) to penetrate the soil surface. These elevated

soil temperatures have been shown to decrease plant pathogens and nematodes. In coastal California strawberry production areas, optimal temperatures can only be achieved during the summer and early fall months before bed establishment and planting. This can be difficult for growers that rotate land use with other growers (e.g., vegetable production).

Steam Treatment. Soil disinfestation by the injection of steam is another option, particularly for substrate-based production. Open field trials have shown that steam can be as effective as chemical fumigation (Shennan et al., 2012); however, it is very expensive compared to chemical fumigation and slow to apply, making it impractical for growers at this point.

While none of these tools have replaced fumigation, each is available to conventional and organic growers and has seen varying degrees of adoption.

Production Summary

- California strawberries are available year-round
 - Strawberry plants are first grown in a nursery and then transplanted into grower's fields
 - California strawberries are hand-picked and field packed
 - Strawberries are grown within five distinct areas of California: Watsonville/Salinas, Santa Maria, Oxnard, Orange County/San Diego, and the Central Valley
 - University of California cultivars make up 57.9% of the total state acreage
 - California dedicates over 4,200 acres to organic strawberry production, more than any other place in the world
-

PEST MANAGEMENT FOR COMMERCIAL STRAWBERRY PLANTINGS

This section tracks the progression of strawberry production under California growing practices. It provides information on typical field activities and important pests which occur during the following distinctive strawberry horticultural and pest management intervals:

- Land preparation through planting
- Vegetative growth (planting to first harvest)
- Fruit development through harvest
- Postharvest

Calendars for crop development and pest presence in major production regions of California strawberries are provided in Appendices 2 and 3.

The critical research, regulatory, and educational issues of the California strawberry industry are summarized at the end of this document.

LAND PREPARATION THROUGH PLANTING

The following list indicates the general order of the various activities that must be completed prior to fumigating the soil.

ACTIVITIES PRIOR TO FUMIGATION

1. Turning in/plowing previous crop
2. Soil testing for nematodes and nutrients, particularly residual nitrogen
3. Soil testing for soilborne pathogens – *Verticillium dahliae*, *Fusarium oxysporum*, f.sp. *fragariae* and *Macrophomina phaseolina*
4. Soil preparation (disking, leveling, etc.)
 - i. If applying flat fumigation, applied across the entire block
5. Apply soil amendments and fertilizers
6. Pre-irrigation for bed establishment
7. Listing (forming) of planting beds
8. Laying of plastic mulch
9. Install irrigation – including laying drip lines
10. Water quality analysis for pH and nitrates
11. Irrigation to germinate weeds prior to planting
12. Herbicide applications
13. Weed clean-up around the fields
14. Submitting regulatory requirements for use of fumigants
 - i. Application of bed fumigation

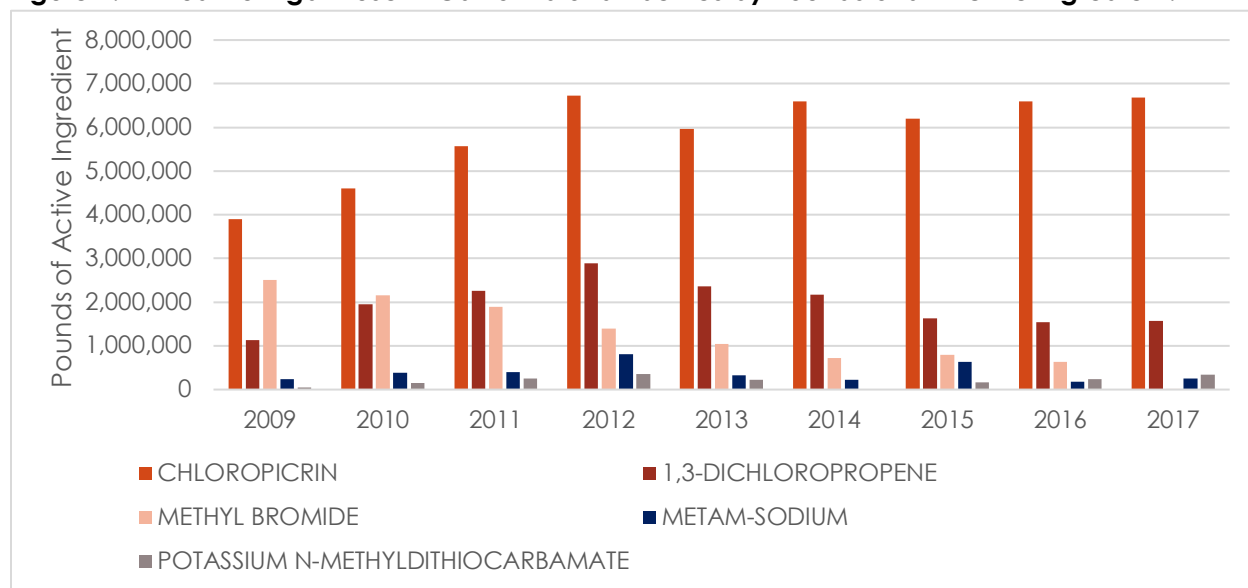
SOIL FUMIGATION

Pre-plant soil fumigations are used to manage soilborne pests, diseases and weeds. With one treatment of fumigant before planting, farmers can reduce their environmental footprint - reducing water use by 50%, reducing all other pesticide use by at least 50%, and reducing the amount of land used by 50%.

Fumigations are described as either “flat fumigation” or “bed fumigation,” meaning that either the whole field or just the beds through a drip system, respectively, are fumigated. Currently, about 50% of California strawberry acres are bed fumigated; however, bed fumigation doesn’t treat furrows and is less evenly distributed, reducing the effectiveness of the application. Overall economic conditions can drive decisions on fumigation, as bed fumigation is less expensive than flat fumigation since it uses less fumigant and less plastic. An additional advantage of bed fumigation over flat fumigation is timing and convenience, because planting can occur quicker following bed fumigation since the beds are already formed, plumbed with drip tape and covered with plastic mulch.

Strawberry production relies on several fumigants. Although organic fields are not fumigated, most conventional acreage is fumigated (Figure 1). Fumigants accounted for about 81 percent of the pounds of all pesticide active ingredients (AIs) applied to strawberries in 2017 (the last year for which pesticide use data is available; California Department of Pesticide Registration, 2018). Historically, methyl bromide, usually in combination with chloropicrin, was the most commonly used fumigant to control nematodes, pathogens and weeds. 1,3-dichloropropene, alone or in combination with chloropicrin was the second most commonly used fumigant and methyl isothiocyanate (MITC)-generating materials Metam-sodium and potassium N-methyldithiocarbamate were also used. MITC generators are generally more effective in controlling a broad spectrum of weeds, but less effective than methyl bromide, 1,3-D or 1,3-D plus chloropicrin against soilborne diseases and nematodes. Chloropicrin is used primarily for disease control either as a standalone fumigant or combined with 1,3-D. Since the phase out of methyl bromide, producers have relied primarily on two fumigants, 1,3-D and chloropicrin with lesser, but important use of MITC generators in some circumstances.

Figure 1. Annual Fumigant Use in California Strawberries by Pounds of an Active Ingredient:



Fumigants usually are applied at higher rates than other pesticide types, such as fungicides and insecticides, in part because they treat a volume of space rather than a surface such as leaves and stems of plants. In addition, fumigants are “heavy” compared to other pesticides, weighing several pounds per gallon, rather than ounces per gallon like typical non-fumigant pesticides. For

example, a mixture of 63% 1,3-D and 35% chloropicrin weighs nearly 11 lb per gallon and 50 gallons per acre may be required. Thus, the amounts applied are large relative to other pesticide types even though the number of applications or number of acres treated may be similar.

The following table shows pests which are effectively controlled with existing fumigants (Table 7):

Table 7. Insects, Diseases and Other Pests of Strawberry Effectively Controlled with Fumigant Applications.

Insects	Pathogens	Nematodes	Weeds
Root weevils, cutworms, strawberry rootworm, white grubs, garden symphylan, ground mealybug	<i>Verticillium dahliae</i> , <i>Phytophthora</i> species, <i>Fusarium oxysporum</i> f. sp. <i>fragariae</i> , <i>Macrophomina phaseolina</i> , <i>Colletotrichum acutatum</i> , <i>Pythium</i> species, <i>Rhizoctonia</i>	Root knot, foliar	All, except certain perennials and broadleaves; does not control malva, clovers, filaree, oxalis, or bindweed

Due to the loss of methyl bromide and increasing restrictions on other fumigants, development of replacement chemicals and strategies for soil fumigants used to manage soilborne pests, diseases and weeds is critical for the survival of California's strawberry industry. Some soilborne diseases previously controlled by methyl bromide like *Macrophomina* crown rot are increasing and have caused significant plant death, leading to economic losses. Methyl bromide alternatives research has been a very active area of research for many years, involving USDA-ARS, the University of California, the Cal Poly Strawberry Center, IR-4, the California Strawberry Commission, individual growers, and others. The strawberry industry has committed over \$13 million toward research for safe fumigant ingredients, fumigant application techniques, and effective emissions reduction.

Alternatives being investigated include methods such as Anaerobic Soil Disinfestation (ASD) for soilborne diseases, steam, substrate systems such as a raised bed trough or tabletop production, cover crops and crop rotations. The need for new chemical controls including the possibility of Dominus® (allyl isothiocyanate) and Paladin® (dimethyl disulfide) were discussed by working group members. Dominus® and another potential alternative, ethyl dinitrile (EDN®) are registered in other states; however, they are not registered for use in California.

To date, no commercially viable alternatives to methyl bromide have been registered for use in California since the methyl bromide phase out. Growers commented that the loss of methyl bromide will result in the need for longer crop rotations.

State and local regulations have also led to restrictions on the use of current fumigants. For example, DPR recently enacted new regulations restricting the timing of applications of fumigants

near sensitive sites, and DPR is currently evaluating changes to 1,3-D labels to account for both acute and cancer exposures.

PLANTING

Commercial strawberry fields are intensively managed for predictable production volume at specific times of the year to meet market demands. Strawberry transplants are held dormant in cold storage until the appropriate planting time, in the fall or the spring, depending on the growing district, cultivar, and cropping cycle. Plant chilling influences plant vigor; more chilling produces more vigorous plants, but over-chilling causes excessive vegetative growth with reduced fruit yield. Optimal chilling also can reduce the impact of spider mite feeding.

Transplants are planted by hand and requires a significant labor input. It takes 15 to 30 days for root and plant development to occur for plant establishment. During this time, overhead irrigation is used to keep plants cool and hydrated. Although flowering can occur immediately after planting, these few early blooms are typically removed by hand so that plants allocate resources to vegetative and root growth. Once the crop is established, the bloom is abundant and left to develop into fruit. Pollination is accomplished via wind, gravity, or insects; no pollinators (honeybees or other types of bees) need to be provided. Further, bees do not prefer to forage on strawberries and evidence suggests that pollinators would prefer to forage on wild plants than provide pollinator services to soft fruit berries (Foulis and Goulson, 2014). Harvestable fruit takes about 25 to 30 days to develop from a pollinated flower. Fields are typically harvested for three to eight months depending on the cultivar, location of the planting and market conditions.

Strawberries are perennial plants and can grow and produce fruit for many years, although in California, they are grown as an annual production system. In the recent past, some growers would keep strawberry fields for two or three years and use mowing or plant trimming to stimulate bloom each year. However, second- or third-year berry production was abandoned due to increased pest pressures and reduced fruit yield and quality after the first year. Thus, strawberries are grown as if they were annual plants and production is terminated as market conditions, fruit yield and quality decline to a point where it makes good economic sense.

WORK GROUP RECOMMENDATIONS FOR PEST MANAGEMENT FROM LAND PREPARATION THROUGH PLANTING

RESEARCH	• Continue research on alternative fumigants and non-fumigant chemical strategies • Develop new cultivars which are resistant to insects and pathogens • Conduct long-term studies on various cultural practices, including steam, anerobic soil disinfestation, and cover cropping as alternatives to fumigation • Conduct research on soil amendments to improve microbial community to encourage "suppressive" soil development • Develop information on soil microbiome and microbiology to determine epidemiology of soilborne diseases
-----------------	--

	• Study emission reduction, particularly for potential alternative fumigants • Conduct research on alternative weed management strategies
REGULATORY	• Retain methyl bromide for nursery production (even organic production requires fumigated nursery stock) • Work with DPR to encourage more timely processing of fumigant registration applications • Re-evaluate and refine fumigant modeling that influences CA regulations and work with registrants and EPA to modify buffer zones as appropriate • Register alternatives to methyl bromide • Encourage more consistent interpretation of label requirements and regulations by County Ag Commissioners • Support science-based application safeguards; support risk-based notification where necessary, not “right to know” notification regardless of risk.
EDUCATION	• Educate the public about fumigation safeguards and benefits • Educate growers as new fumigant alternatives come to market • Continue to provide media training to growers regarding fumigants and their application • Continue educational activities with growers and the public about production challenges facing the strawberry industry since the use of fumigants has been severely restricted • Involve California Association of Pest Control Advisors (CAPCA) and other organizations in educating growers and the public • Continue to educate regulators about strawberry growing practices and pest management issues

PLANT ESTABLISHMENT (AFTER PLANTING UP TO ROOT ESTABLISHMENT)

After transplanting, adventitious roots grow from the stem tissue of the plant crown. The root system continues to establish itself during the first two to three months after planting, as soil temperatures increase. Plastic mulch is commonly used to help increase (or decrease) soil temperatures and promote plant growth. The mulch also aids in controlling weeds and reducing irrigation requirements.

Throughout this period, it is very important that the crown remains in contact with the soil and that the correct amounts of water and nutrients are provided. Salinity of the soil and water is continually monitored since high salt levels can slow plant growth or even cause plant death. Strawberry is one of the most salt-sensitive crops grown (FAO, 1999) and salinity is managed throughout the growing season to optimize plant growth.

Diseases during this period include soilborne and plant borne diseases affecting plant establishment (*Phytophthora* root rot, anthracnose) and above-ground diseases such as angular leaf spot and *Zythia* leaf blotch. As a water-loving pathogen, *Phytophthora* is more likely to occur

in wet years when prolonged periods of standing water may occur. Anthracnose generally arises from infected transplants. Both diseases can kill plants during stand establishment and fungicides are applied via drip irrigation or as transplant dips immediately prior to planting.

Angular leaf spot and Zythia leaf blotch are usually present at low levels in most fields. However, neither disease causes significant losses in most years. Angular leaf spot is more prevalent in wet years, since the pathogen is spread via splashing water. The disease affects leaves, but can also affect the calyx, especially under favorable conditions (e.g., high rainfall and heavy dew/persistent wet leaves). Zythia leaf blotch is common, but usually occurs at low levels and does not persist much beyond the spring season.

Mite and whitefly control can become important, as relatively low densities of these pests can result in yield loss and excessive pest populations later in the production season.

CULTURAL ACTIVITIES DURING PLANT ESTABLISHMENT

- Irrigation
- Water quality analysis
- Insect, mite, and disease monitoring and control
- Fertilization
- Herbicide applications
- Weeding in plant holes and field perimeter/field sanitation
- De-blossoming, especially for day-neutral cultivars
- Vacuuming to remove insects that can cause fruit damage

WORK GROUP RECOMMENDATIONS FOR PEST MANAGEMENT IN CALIFORNIA STRAWBERRIES DURING PLANT ESTABLISHMENT

RESEARCH	• Develop new cultivars that are resistant to pests and diseases • Identify treatments effective against Phytophthora and anthracnose (e.g., drip-applied or transplant dips) • Develop information on soil microbiome and microbiology to determine epidemiology of soilborne diseases
EDUCATION	• Continue educational activities with growers and the public about alternatives to methyl bromide and about safe fumigation practices

VEGETATIVE GROWTH

Pest management is extremely important during this phase, when young transplants adapt to their new location, break dormancy, and develop runners and new crowns. This period of development lasts 60 to 90 days, depending on the cultivar, location, and seasonal temperatures.

CULTURAL AND WORKER ACTIVITIES

- Irrigation
- Fertilization
- Water analysis
- Irrigation monitoring
- Pest monitoring
- Visual inspections of plant health/vigor
- Plant removal
- Insecticide, miticide, and fungicide applications
- Dust control (water/oil roads)
- Petiole or plant tissue analysis
- Replanting
- Removing runners
- De-blossoming
- Hand weeding
- Releasing beneficial insects
- Sanitation
- Plant and establish trap crops
- Vacuum fields to remove insects that can cause fruit damage

INSECTS AND MITES

Insect and mite pressure vary according to location and season. Neighboring crops can also influence pest pressure, by providing overwintering or alternate habitats. While the single most serious pest of strawberries is the two-spotted spider mite (*Tetranychus urticae*), worms, aphids, and whiteflies can also cause concern during this stage of strawberry development. Some general predators, such as big-eyed bugs, minute pirate bugs, damsel bugs, spiders, and ladybird beetles, as well as phytoseiid/predatory mites provide limited biological control of these pests. Some naturally occurring parasitoids also provide biological control of moderate infestations of aphids, whiteflies and some worms.

Twospotted Spider Mite

The twospotted spider mite, a key pest of strawberries in all California growing areas, damages the fruit and leaves causing stippling, scarring, and bronzing of the leaves and calyx and plant stunting. This damage can be minimized by using cultural practices that promote vigorous plants, but strawberry cultivars vary in susceptibility to twospotted spider mite infestation and tolerance of mite feeding. In general, mite populations tend to be greater on day-neutral cultivars than short-day cultivars. Mite populations must be carefully monitored throughout the season and products should be rotated to manage the development of resistance. Controlling road dust is also important in inhibiting mite infestations because dusty conditions favor the build-up and dispersal of twospotted spider mites. In recent years, microsprinklers have been used to control mites by washing dust from leaves and hydrating above-ground plant parts on a regular basis.

Cyclamen Mite

While cyclamen mite (*Phytonemus pallidus*) can be an important pest of strawberries, annual production systems are not favorable to its survival and infestations in annual plantings are most commonly associated with infested nursery stock. Cultural controls of this pest include preventing movement of this species from infested plantings by pickers and equipment, including strawberry freezer trays. When using chemical controls for cyclamen mites, a high rate of water per acre is necessary to soak the unfolded leaves and immature flower buds located in the crowns. Crop rotation, dust reduction, and biological control provide limited management of this pest. Six-spotted thrips, an important natural enemy, feed on cyclamen mites when they become prevalent.

Mite Management

Releases of predatory mites (*Phytoseiulus persimilis*) can reduce twospotted mite populations, especially early in the season when miticides are not being used. Timing of beneficial insect release is particularly important to establish a population before twospotted spider mites build to damaging levels, as well as taking into consideration environmental conditions. In addition, *P. persimilis* does not provide effective control for Lewis mite (*Eotetranychus lewisi*), sometimes observed in organic production fields. In fields where Lewis mite is present, *Neoseiulus californicus*, another predatory mite, must be released to provide effective control. However, biological control alone rarely provides control of spider mites enough to prevent yield loss.

Releases of predator mites, minute pirate bugs, ladybird beetles, six spotted thrips, and a cecidomyiid fly maggot (*Feltiella* spp.) have all been used as biological controls in strawberries. Of these, only predator mite releases are commonly employed. Predator mites are most effective when used in controlling light infestations of mites. These biological control methods for mites are typically used in conjunction with chemical pest management techniques because these combinations are much more effective than biological control alone. Some growers have had success integrating organic materials such as oils with conventional pesticides. Since nurseries may also treat for mites, there is a need to coordinate with nursery growers to do more strategic pest control. Cultural practices are also employed and include applying water to roads around the fields, erecting dust barriers, planting wind breaks, planting plants (ryegrass, cilantro, wildflower blends, etc.) at the end of the rows, and micro sprinklers.

Chemicals are extremely important pest management tools for strawberry growers, but twospotted spider mites have rapidly developed resistance to many miticides (Van Leeuwen et al., 2010). Rotating chemical classes with different modes of action helps to reduce resistance development to individual miticides. However, pyrethroid insecticide applications can stimulate twospotted spider mite outbreaks by disrupting the balance with beneficial arthropods.

The following summarizes available mite control materials:

- Abamectin (Agri-Mek®) remains an effective miticide for cyclamen mite control.
- Bifenazate (Acramite®) was quite reliable in controlling twospotted spider mite when originally registered, but its efficacy has become erratic for several years.

- Hexythiazox (Savey®) is an ovicide and provides very good control of twospotted spider mite eggs; however, it is most effective when used early in the season before high populations occur.
- Etoxazole (Zeal®) is a mite growth regulator that causes reduction in egg-laying by twospotted spider mite females and virtually complete sterility of those eggs for an extended period.
- Spiromesifen (Oberon®), fenpyroximate (Fujimite®), acequinocyl (Kanemite®), and the recently available cyflumetofen (Nealta®) are not as widely used as are the previously mentioned miticides, but they represent different modes of action and should be considered as alternatives where resistance management is an issue.
- Fenpyroximate is also very effective against cyclamen mite. Successful control of twospotted spider mite with fenpyroximate (Fujimite®), Acequinocyl (Kanemite®), and cyflumetofen (Nealta®) requires the highest label rate and maximum product concentration that still provides acceptable coverage.
- Fenbutatin-oxide (Vendex®) provides only poor to fair control of mites.
- Omni Supreme® oil can be used effectively during cool weather before flowering to reduce overwintering mite populations and is a useful practice when predatory mite releases are anticipated in spring, but caution is necessary to avoid phytotoxicity.
- Abamectin (Agri-Mek®), bifenazate (Acramite®), and acequinocyl (Kanemite®) are all minimally toxic to predator mites, while etoxazole (Zeal®) and fenpyroximate (Fujimite®) are harmful to them for at least 40 days after application.

Organic options for mite control are limited, but include sulfur, various horticultural oils, microbial-based insecticides (Grandevo®) and bioinsecticides (Venerate®). Some growers incorporate organic applications to conventional fields to provide more options and reduce high-resistance risk material applications.

During working group meetings, many participants expressed concern about the varying efficacy of current miticides. For many miticides, pH of the water used in the application is important for optimum efficacy and should be adjusted appropriately. There is also a need for resistance management education and information for pest control advisors and those making integrated pest management decisions, particularly when new products are released. Participants also expressed a desire to better coordinate pesticide application programs with nurseries and growers of surrounding fields (e.g., raspberry, blackberry, etc.) to prevent resistance of particular chemical classes.

Black Cutworms, Rough-Skinned Cutworms, and Beet Armyworms

Worms can be important lepidopterous pests of strawberries, but their damage is rather limited to certain production areas. Damage by the cutworms is largely confined to fields on inland Central Coast fields, associated with pastoral fields nearby which serve as alternate weed hosts. Weed control is paramount to preventing a serious cutworm problem; weedy fields attract more moths to lay their eggs. Early-season damage by newly hatched cutworms generally appears as small, silkless perforations in the newly expanding crown leaves. As soon as substantial leaf and/or stem cutting is noted, baits are applied; bait applications are also made immediately after weeding to prevent migration to crop plants.

The greatest damage from beet armyworm occurs to summer and fall-planted strawberries in the southern growing regions of the state where the insect can build on other crop hosts. Newly hatched beet armyworms are foliage feeders, skeletonizing the upper or lower leaf surfaces adjacent to their egg mass. Young larvae feed on foliage before attacking fruit. Larger larvae can attack the crowns of young plants and kill them, and this represents the most significant damage for growers. Weed control in and near the field minimizes armyworm populations because the adult moths have a wide host range and are attracted to weeds for egg laying. Biological control is provided by the ichneumonid parasite, *Hyposoter exiguae* and other parasitoids, and armyworms often become diseased with a virus that can cause high mortality.

Bacillus thuringiensis (Bt) can provide fairly good control of lepidopterous pests, but Bt must be applied shortly after egg hatch against the newly emerged larvae, and multiple applications are usually required to maintain acceptable control levels. Intrepid®, an insect growth regulator, is quite effective against cutworms and armyworms, and compatible with biological control organisms. The spinosyn insecticides including Radiant®, Success® and Entrust® work well on beet armyworms and are compatible with many beneficial insects, however Success® and Entrust® are ineffective on cutworms. Lorsban® and diazinon provide fair to good control of worm pests in strawberries but concerns for water quality must be considered. Their rather long re-entry and pre-harvest intervals limit their use to early season application for practical purposes. Brigade®, Danitol® and other pyrethroid insecticides also provide good worm control, but they are harsh on beneficials and their use should be restricted to lygus and other hard-to-control pests.

Aphids

Aphids occasionally cause yield losses in California strawberries because of their sticky honeydew production, which renders fruit unsaleable. They also transmit several viruses that can cause significant economic losses if fruit plantings are maintained for more than one year (e.g., second or third-year fields). A cultural control effective for aphids is row covers, but this is not commercially viable because of cost and the labor required to remove them and recover when harvesting.

Biological control of aphids is assisted by conserving parasitic wasps, lacewings (especially nymphs), big-eyed bugs, minute pirate bugs, damsel bugs, and lady beetles. In some circumstances, biological control is sufficiently effective to provide an economically viable alternative. Thus, growers should monitor aphid populations and avoid applications of broad-spectrum insecticides/miticides that will destroy natural enemies. Lady beetle releases are not effective in controlling aphids due to their habit of migrating from the fields to foothill locations where they were originally collected and lack of establishment. Removing weeds in strawberry and nearby fields that harbor aphids also will help to manage populations.

When aphid pest pressure reaches the economic threshold (e.g., 30% of young tri-foliolate leaves infested), chemical treatments are made. Neonicotinoids including Admire® (applied at transplant), Actara® and Assail® provide good control of aphids. Diazinon, malathion, and chlorpyrifos (Lorsban®), all organophosphate insecticides, provide only fair control of aphids and harm beneficials. Stylet oil, summer oils and insecticidal soap work well but can cause phytotoxicity to plants and are disruptive to beneficials. Azadirachtin works moderately well but requires multiple applications and it is very expensive.

Whiteflies

Whiteflies feed on the veins of the leaf (phloem), and at high population levels, can excrete large amounts of honeydew on which a sooty mold fungus grows. The greenhouse whitefly (*Trialeurodes vaporariorum*) is the most damaging species found in strawberries. Occasionally populations build up to damaging numbers causing economic loss. They can be found in all growing regions, but the importance of this pest tends to vary geographically from season to season.

An area-wide approach to greenhouse whitefly management is essential for control because of its broad host range and overlapping crop host cycles. This approach involves breaking the continuous generation cycles of this pest by cultural or chemical means. For example, multiple-year plantings should be avoided in areas where whiteflies become especially problematic, and hosts which are no longer being harvested should be destroyed before new strawberry plantings are established. Trap crops have proven only marginally effective and can even serve as bridge hosts if not selected wisely. The use of sticky traps is not effective as a control measure, other than to use in scouting activities. Conservation of naturally occurring parasitoids can reduce the abundance of greenhouse whiteflies but released *Encarsia* and *Eretmocerus* parasitic wasps are costly and are generally ineffective in strawberry fields.

Admire® provides good control of whiteflies when applied after plants are transplanted and according to labeled rates. Esteem®, an insect growth regulator can be used after harvest begins but can take 2 to 3 weeks to impact populations, so it is most effective if used before damaging populations are reached. Danitol® in combination with Malathion and the neonicotinoid Actara® provide fair control of whiteflies after harvest has begun, but malathion, Danitol®, and Brigade® by themselves are not effective against whiteflies. Azadirachtin provides poor control of whiteflies.

WORK GROUP RECOMMENDATIONS FOR INSECT AND MITE MANAGEMENT IN CALIFORNIA STRAWBERRIES DURING VEGETATIVE GROWTH

RESEARCH	• Research alternatives to fumigation for control of soil insects • Develop a resistance management strategy for certain pests • Research additional biological controls, including rearing, efficacy, and survivability • Research impacts of new materials on beneficial insects and IPM programs
REGULATORY	• Register new products for key insect and arthropod pests • Work with pesticide registrants to shorten restricted entry interval (REI) for certain products when plausible • Change label to eliminate bloom restriction on certain products • Correct misinformation on pollinators which regulators use to make decisions • Maintain access to current products
EDUCATION	• Provide resistance management training for PCAs and growers • Coordinate with nurseries on education programs to combat resistance

	• Develop educational materials targeted to minority growers (Spanish, Mixtec, Hmong, etc.) • Educate regulators regarding pests for which resistance management strategies are critical and on any strategies that have been developed
--	--

WEEDS

Strawberry nursery stock is grown in soils previously fumigated with methyl bromide plus/chloropicrin, or in some cases 1,3-dichloropropene (1,3-D)/chloropicrin to produce certified pest- and disease-free nursery stock. In the fruiting field, conventional strawberries are grown on soils primarily fumigated with 1,3-D/chloropicrin. Weed control results with 1,3-D/chloropicrin are generally inadequate and supplemental fumigants such as metam-potassium are used as well as pre-transplant applications of oxyfluorfen or flumioxazin herbicide.

California's long growing season presents a significant weed control challenge (Table 9). Strawberries are highly susceptible to weed competition immediately after transplanting, when the plants are small and frequent watering provides ideal conditions for weed germination. Most weeds that invade strawberries are annuals. During stand establishment, little mallow, California bur clover, sweet clover, and filaree are common because their seeds survive fumigation. Wind-blown seeds, including those of sowthistle, common groundsel, purple cudweed, hairy fleabane, and horseweed, may become problems if areas surrounding the field are not kept clear of these weeds.

Table 8. Annuals and Perennial Weeds of Significance to California Strawberry Production

Annuals:	Perennials:
• Annual bluegrass • Spotted spurge • Sweet clover • Cudweed • Hairy fleabane • Horseweed • Knotweed • Filaree • Little mallow (cheeseweed) • Sowthistle • Common groundsel • California bur clover	• Field bindweed • Yellow nutsedge

Effective weed management in strawberries requires a combination of cultural practices, pre-plant soil fumigation, and additional herbicide applications when necessary. Proper pre-plant field preparation and bed preparation are essential for a good, season-long weed control program. While traditionally broadcast (flat) fumigation has provided good control of weed populations across the entire field, the use of bed fumigation leaves row middles untreated, allowing weed populations to build up. Weeds that have escaped fumigation treatments may be controlled using directed sprays of contact and systemic herbicides.

Gramoxone® is a good contact herbicide when used as a directed spray. It works well when mixed with a residual product like Chateau®. Sethoxydim (Poast®) and clethodim (Select®) are good grass herbicides. Select® has the added benefit of controlling annual bluegrass, but it must be used prior to bloom. Neither of these products controls nutsedge. GoalTender® is registered for use on strawberry fallow beds 30 days prior to transplanting and provides good control of little mallow. Chateau® at 2-3 oz/A is registered for use >30 days prior to strawberry transplanting. Chateau® can also be applied as a shielded application to the furrow bottoms after transplanting, but prior to fruit set.

There is a need for new chemical and non-chemical strategies for weed control on bed tops and in the furrows. The lack of effective products is exacerbated by lack of labor which can limit hand weeding. Weeding times vary by field and timing. A 2011 cost study attributed 40 percent of IPM costs to hand weeding (Klonsky, 2011). Hand weeding requires significant labor resources and time. Several production practices require hand labor, including hand weeding, transplanting, runner cutting, irrigation, equipment operation, transportation and harvesting. If there are enough laborers and growers can afford them, then fruit is efficiently harvested and delivered to the market. However, in the case of the current labor shortage, growers will need to adapt.

Increasing buffer zone requirements leave sensitive areas treated with only low doses of fumigants or no fumigant at all. Weed control in these buffer areas must be addressed, and increased use of herbicides is the most logical control measure.

Weed management is essential in organic production because weeds compete for resources, reduce yields and can act as alternate hosts for soil pathogens. Weeds are more difficult to manage in organic strawberry operations because many weed management tools available to conventional growers, such as soil fumigation and herbicides, are not allowed in organic production. The primary weed management tools for organic strawberry growers are choosing fields with a history of low weed pressure, sanitation, hand weeding, crop rotation, soil solarization, and plastic mulches. See University of California Publication 3531: *Organic Strawberry Production Manual* Chapter 5: *Weed Control in Organic Strawberries* for more details on weed management in organic strawberry.

One product that is not registered in California but was discussed as a possible material for the future is Dominus® (allyl isothiocyanate [AITC]). Dominus® is a soil biofumigant developed by Isagro USA® to control soil-borne fungi, nematodes, weeds and insects. Dominus® may be used as a stand-alone treatment using conventional tools and equipment. The registrant (Isagro USA) is seeking a full registration in California. Some working group members commented that Dominus® is weak against weeds at 40 gallons per acre (highest label rate).

WORK GROUP RECOMMENDATIONS FOR WEED MANAGEMENT IN CALIFORNIA STRAWBERRIES DURING VEGETATIVE GROWTH

RESEARCH	• Evaluate cultural and chemical techniques for control of nutsedge – particularly metolachlor (Dual Magnum®) and determine if Zeus® (sulfentrazone) can control nutsedge • Identify alternative fumigants that can be used in the buffer zones • Develop new chemical and non-chemical strategies for weed control on bed tops and in furrows • Develop/research herbicides that can be injected through drip systems during the winter to supplement preplant herbicides • Develop weed management options and techniques for use in organic systems (e.g., ASD, steam, solarization, etc.) • Use precision tools to map where the worst weeds and pathogens are in organic fields so that aggressive methods such as steam can be focused on the most difficult sections of the field. • Evaluate cultural methods to manage weeds in buffer areas (e.g., anaerobic soil disinfestation, steam and other non-fumigant alternatives) to allow growers to crop these areas with strawberry
REGULATORY	• Register new herbicide chemistries and modes of action with effective weed control
EDUCATION	• Provide training to growers and PCAs on nutsedge management • Develop educational materials targeted to minority growers (non-English, etc.)

DISEASES

Disease management begins before field preparation. Proper site selection, fumigation, drainage, use of resistant cultivars and certified, vigorous planting stock will help to establish a healthy crop.

Root and Crown Diseases

Root, crown and wilt diseases are caused by pathogens present in the soil or water and/or on infected transplants. Soil fumigation and use of disease-free transplants are the major ways to prevent these diseases. With the phase-out of methyl bromide, soilborne diseases have become the most economically important diseases in strawberries.

Verticillium Wilt

Verticillium wilt, caused by *Verticillium dahliae*, progresses slowly but once established in soil, is extremely difficult to manage. Spread of the disease from contaminated planting stock is an increasing concern, making control of this disease at the nursery stage crucial. Verticillium wilt is also an important disease of lettuce and leafy greens which are the most common rotational crops for strawberries. Cultural controls include using resistant cultivars, limiting over-fertilization,

rotating to non-host crops, and controlling irrigation to limit over-watering. In combination with these tactics, chemical fumigants help to reduce losses from *Verticillium* wilt, however the most effective fumigant (methyl bromide) is no longer available.

Ongoing research has identified several fumigants with varying degrees of efficacy against soilborne diseases. Fumigants being investigated include Dominus®, Palladin® and EDN®. Dominus® is registered in many other states but is awaiting approval by the California Department of Pesticide Regulation. Palladin® and EDN® are not likely to be registered in CA.

Fusarium Wilt and Macrophomina Crown Rot

Both *Fusarium* wilt and *Macrophomina* crown rot (also known as charcoal rot) are diseases that have emerged during the phase-out of methyl bromide and are becoming more widespread, causing greater economic losses each year. They cause plant death by attacking roots, crowns or the vascular system. Both fungi survive in the soil for many years and are difficult to control with existing registered fumigants. *Macrophomina* crown rot is more common in the southern districts where it is promoted by high temperatures and is more severe when plants are stressed by lack of nutrients or water. Resistant cultivars exist for *Fusarium* wilt, but levels of resistance to *Macrophomina* crown rot are only recently being investigated. However, simply using resistant cultivars has limitations, as the disease can continue to build to levels that may overcome simple genetic resistance. Crop rotation, anaerobic soil disinfestation and other soil treatments have been partially successful and have limited adoption, especially with organic growers.

Phytophthora Root Rot

Phytophthora is a water-loving, fungal-like soilborne organism that causes plant stunting, wilting and death. *Phytophthora* species also attack root tissue, causing a brown to black root rot. Cultural control of the fungus includes locating strawberry fields on well-drained soil, using raised beds to provide optimum drainage, and using less susceptible cultivars. Using drip irrigation and managing irrigation schedules to minimize soil saturation near plant crowns are key methods to reduce losses from this pathogen. Aliette® (and other phosphonate fungicides) and Ridomil Gold® also provide good control of these diseases.

Anthracnose

Anthracnose, caused by *Colletotrichum acutatum*, is an important disease of strawberry that affects all parts of the plant including the root, crown and fruit. Because the fungus does not persist in soil for more than a few months, its introduction is usually by means of infected planting stock. Thus, nursery sanitation is the main means of excluding the pathogen. Severe root infections can cause plant establishment problems, stunting or killing plants and reducing yields. Dipping transplants in Abound® or Switch® immediately prior to planting will reduce the severity of the disease. Resistance to strobilurin-based fungicides (e.g., Abound) has been documented and when insensitive strains of the pathogen are present, this treatment is ineffective (Forcelini et al., 2016). In severe cases, replanting with disease-free transplants may be necessary.

Black Root Rot

Black root rot is a disease complex caused by the combined interaction of several soilborne pathogens (e.g., *Pythium*, *Fusarium*, *Rhizoctonia* and nematodes) and environmental conditions (water-logged soils, soil compaction and drought). The disease is not common in CA but is very common in other states. Cultural controls for black root rot include crop rotation and water management. The fungicides Aliette® (and other phosphonate fungicides) and Ridomil® Gold provide good control of *Pythium*.

Foliar and Fruit Diseases

Most foliar diseases of strawberries are spread by rain or splashing water, and some are brought to the field on infected transplants. Monitoring fields for signs and symptoms of diseases is critical throughout the growing season. Clean nursery stock is essential for minimizing all diseases. There is a need for coordination of fungicide programs between nurseries and fruit production fields to maximize efficacy and reduce the development of fungicide resistance.

Powdery mildew

Powdery mildew caused by *Podosphaera aphanis* is a significant disease in the nurseries and fruit-growing fields. It is most serious in areas of high humidity (e.g., high tunnel production systems). Cultivar susceptibility varies considerably with no cultivars possessing complete resistance. Cultivars such as 'Chandler', 'Albion', 'Florida Radiance', 'Sweet Ann', and 'San Andreas' have partial field resistance, while 'Camarosa', 'Seascape', 'Ventana', 'Portola' and 'Monterey' are more susceptible. The disease is a problem on all plant parts from transplant through bloom, reducing yield and quality. Powdery mildew is controlled by applying fungicides as soon as the disease is detected; thus, monitoring is extremely important in reducing disease incidence. New succulent growth is the most susceptible to the disease. Thus, fungicide application should be timed when plants have a flush of new growth (e.g., early spring). Typically, fungicides are applied about one month after planting and again three to four weeks later.

Two formulations of sulfur provide good control of powdery mildew but micronized and dusting sulfur can cause phytotoxicity problems if temperatures are over 85-90°F. Microsprinklers are sometimes used to apply sulfur. Several fungicides are labeled for use (Appendix 8), but poor performance in strawberry fields points to a need to characterize sensitivity of the pathogen to these fungicides (Sombardier et al., 2010). Potassium bicarbonate works well, but requires multiple applications, and cannot be mixed with other pesticides or fertilizers. In fields which are thought to have powdery mildew problems, "Bug Vac" devices used to physically remove lygus bugs will spread powdery mildew spores, but the impact of this practice on powdery mildew has not been documented.

Botrytis Fruit Rot

Botrytis fruit rot is the most important disease affecting fruit, both pre- and post-harvest. The spores of this pathogen are wind- and splash-dispersed. The pathogen infects flowers during wet or foggy weather, but the disease does not become apparent until the fruit ripens or after harvest. Effective control requires applications of fungicides during flowering. Since strawberry plants are continuously blooming, fungicides are typically applied on a 7- to 14-day interval throughout

harvest. This requires several different fungicides with different modes of action to effectively control the disease and prevent resistance development (see Appendix table 7). Resistance has been reported to FRAC Groups 1, 2, 7, 9 and 17 which contain many of the fungicides currently in use (Cosseboom et al., 2019). Coordination of fungicide programs is needed between nurseries and fruit production fields to maximize efficacy and minimize the development of resistance.

Common Leaf Spot

Common leaf spot, caused by *Ramularia tulasneii*, is the most important strawberry leaf spot disease worldwide, but it is rarely a commercial concern in California. The disease can be a problem in all fruit production areas but is usually less prevalent in the drier interior valleys and southern growing regions. The use of drip irrigation can limit the onset of the disease; avoid use of overhead sprinklers. Many of the fungicides used against Botrytis fruit rot and powdery mildew are active against common leaf spot.

Other Leaf Diseases

Angular leaf spot, caused by the bacterium *Xanthomonas fragariae* and leaf blotch, caused by a fungus, *Zythia fragariae*, are common diseases seen in all growing districts and nurseries. The disease spreads via water splashing from rain or irrigation and is more prevalent in wet years. Since angular leaf spot is caused by a bacterium, copper products have been applied, but with little effectiveness. Genetic resistance has been identified for angular leaf spot, and new cultivars are being developed with this resistance (Roach et al., 2016).

Strawberry leaf blotch is often detected after heavy, prolonged rainfalls, but seldom requires fungicide applications since the disease typically is eliminated as temperatures rise and plants mature.

Viruses (mottle, crinkle, mild yellow edge, vein banding, and necrotic shock) may affect strawberry plants. Most are spread by insects, and usually more than one virus is present in a symptomatic plant. Using clean nursery stock is the primary means of excluding viruses. Vector control is only minimally effective because the diseases are usually established before control actions are taken. There are no chemical controls, and little-known vector or virus resistance.

Phytoplasmas, such as lethal decline and green petal, are transmitted by leafhoppers. As with viruses, using clean transplanting stock is the best way to exclude these diseases. Leafhopper control is only moderately effective.

Cultural controls for disease management include crop rotation and cover cropping, and these practices are particularly important for organic strawberry production. However, due to the high cost of leased land, crop rotations tend to be cost prohibitive. Working group members discussed the need to study soil microbiology so that the dynamics and epidemiology of diseases are understood. In addition, as pests increase due to the reduction of fumigation effectiveness, there is a greater need for clean nursery stock. More coordination is needed with nurseries to prevent pesticide resistance development.

WORK GROUP RECOMMENDATIONS FOR DISEASE MANAGEMENT IN CALIFORNIA STRAWBERRIES DURING VEGETATIVE GROWTH

RESEARCH	• Develop information on the epidemiology and control of anthracnose • Determine if fungicide resistant populations of powdery mildew, gray mold, and anthracnose have developed to commonly used fungicides • Develop improved methods to produce pathogen-free transplants (nursery best practices) • Evaluate nutrient status of plants and soil as these factors relate to disease management • Identify genetic resistance to Verticillium wilt, Fusarium wilt and Macrophomina crown rot and incorporate into new cultivars • Identify genetic resistance to powdery mildew and angular leaf spot and incorporate into new cultivars
REGULATORY	• Harmonize international tolerances, especially for new U.S. registrations • Maintain activity in IR-4 and an active pipeline of product registrations for strawberry diseases • Reduce duplication of the registration process, specifically the duplication of EPA's process taking place at the Department of Pesticide Regulation (DPR)
EDUCATION	• Provide training on fungicide resistance management for growers and PCAs • Educate the public on the benefits of fungicides in producing high quality fruit with improved shelf life • Educate growers on how to prevent pathogen spread by equipment and personnel contamination • Facilitate communication between nurseries and growers on fungicide resistance issues

NEMATODES

Root knot and foliar nematodes are the most important plant parasitic nematodes detected in soils from California strawberry fields. Plant parasitic nematodes feed on roots, reducing water and nutrient uptake, and, ultimately, vigor and yield of plants. Foliar nematodes cause dwarfing or leaf distortion.

There are few instances of economic losses due to nematodes in California. Nematodes are not likely to be pests if the soil has been fumigated and clean planting stock is used. In certain cases, however, nematodes can remain deep in the soil, protected from fumigations by organic matter and other plant debris. Fumigation has generally been an effective means to reduce losses due to nematodes. However, with the phase-out of methyl bromide there could be an increase of root knot nematodes in California strawberries. Telone® (1,3-D) is an effective fumigant for nematode control.

Non-chemical tactics used for managing nematodes include careful field selection, use of clean nursery stock, hot water treatments, sanitation, crop rotation, and soil solarization.

WORK GROUP RECOMMENDATIONS FOR NEMATODE MANAGEMENT IN CALIFORNIA STRAWBERRIES DURING VEGETATIVE GROWTH

RESEARCH	• Develop nematode-resistant cultivars • Conduct a survey of strawberry production regions to determine the amount and distribution of root-knot nematodes in strawberry production fields • Conduct research on post-plant options for nematode control and their efficacy
----------	---

VERTEBRATE PESTS

Several vertebrate pests may move into or live near strawberry fields: birds, squirrels, mice, moles, and gophers are the most common. Searching for water and food, they may damage the crop or the irrigation system. The potential for damage by vertebrate pests varies from field to field and region to region. Fields located near uncultivated areas are more likely to be invaded or re-invaded by certain vertebrates. Whole plants and substantial portions of fields may be lost to these pests. Controls include poison baits, noisemakers, repellents, protective netting, trapping, and lethal control. Restrictions on lethal control will vary by county. DPR is considering new restrictions on use of anticoagulant rodenticides. In addition, new requirements for the registration process to comply with the requirements of the California Environmental Quality Act that a registration will not hurt the “flora, fauna nor human health” in California may bring additional scrutiny to control of rodents, particularly if they could also impact endangered rodent species.

WORK GROUP RECOMMENDATIONS FOR VERTEBRATE CONTROL DURING VEGETATIVE GROWTH

NO RECOMMENDATIONS WERE MADE BY THE WORKING GROUP.

FRUIT DEVELOPMENT THROUGH HARVEST

CULTURAL AND WORKER ACTIVITIES

- Irrigation
- Fertilization
- Soil testing for nutrients
- Visual inspections of plants
- Insecticide, miticide, and fungicide applications
- Irrigation monitoring
- Petiole or plant tissue analysis
- Harvesting every 3 to 5 days (PHIs must allow for this activity or the pesticide cannot be used)
- Pest monitoring
- Hand weeding as needed

It takes 25-30 days for a strawberry flower to mature into a harvestable fruit. Hand-harvesting continues for several months on a three to five-day interval until the field's productivity diminishes significantly. During the lengthy period in which a field is in production, mites, insects, diseases, and birds are continually monitored and managed.

INSECTS AND MITES

The insects and mites that infest strawberry fields during this period are basically the same as those that occur in the vegetative stage, although individual species vary in some cases. Besides mites, worms, whiteflies, and aphids, lygus bugs, thrips, and vinegar flies must be carefully monitored. Biological and cultural controls are used for some of these pests when effective and practical; however, chemical controls remain the primary means to combat pests once fruiting has begun. However, products are somewhat limited to those that have acceptable pre-harvest intervals (PHIs) of 0 to 2 days.

Twospotted spider mites are the major target for mite-control products during fruit development through harvest and are like those used for early season mite control. Agri-mek® has been the standard miticide used for the last 20+ years, but resistance has become a major problem in many regions. Vendex® (fenbutatin-oxide) is an older product that has recently provided only poor to fair control of mites.

Acramite® was quite reliable in controlling twospotted spider mite when originally registered, but its efficacy has become erratic for several years. Savey®, an ovicide, provides very good control of twospotted spider mite eggs, however, it is most effective when used earlier season before high populations occur. Zeal® is also a mite growth regulator that causes reduction in egg-laying by twospotted spider mite females and virtually complete sterility of those eggs for an extended period. Oberon®, Fujimite®, Kanemite®, and Nealta® are not as widely used as are the previously mentioned miticides, but they represent different modes of action and should be considered as alternatives where resistance management is an issue. Fujimite® is also very effective against cyclamen mite. Successful control of twospotted spider mite with Fujimite®, Kanemite®, and

Nealta® requires the highest label rate and maximum product concentration that still provides acceptable coverage.

Horticultural oils, organic oils, essential oils like rosemary or cotton may be used for organic production. Biological controls like Oberon® (spiromesifen) can be used, however timing of application is very important. Coverage is very important and there is a need for more research on use and optimization of biological controls. For example, *P. persimilis* are good cool season predators but without an adequate food source do not persist in the crop when pest mite populations have declined. Other beneficial mites like *N. californicus* may be present in a field without supplemental release.

Lygus bugs are one of the major causes of irregularly shaped, cat-faced strawberries, and a major insect pest of California strawberries. Lygus bug feeding is one of the most important direct causes of fruit deformity, resulting in an estimated \$100 million in economic loss to the strawberry industry annually. Growers are implementing both chemical and non-chemical controls. However, current tools are not enough to manage this pest and additional tools are needed to strengthen IPM and facilitate resistance management planning to preserve the longevity of existing and recently registered pesticides.

Monitoring fields for nymphs and adult lygus bugs are critical to their control. Successful management of lygus bugs includes control of weed hosts along roadways, ditches, and field borders during the winter months which helps prevent spring build-up of lygus bugs. Monitoring for the appearance of lygus nymphs on weed hosts can indicate when the weeds should be removed as well as providing a biofix for predicting when adults resulting from these nymphs might move into the production fields. Some growers use trap crops to attract lygus away from strawberry fields, but the flowers must be maintained or the lygus will migrate back to the strawberries.

Naturally occurring predators that feed on the nymphal stages of lygus bug include bigeyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), minute pirate bugs (*Orius tristicolor*), and several species of spiders. *Anaphes* parasitoids have been shown to provide rather limited control. No single natural enemy has been shown to be successful in keeping lygus from reaching damaging levels after there is a heavy migration of adults into strawberry fields once their alternate host vegetation dries up in the spring but conserving the community of natural enemies present is a useful goal.

Many growers run bug vacuums throughout the season to combat lygus. In all growing districts, over 80% of growers use bug vacuums to control lygus bugs. This cultural practice has increased particularly as chemicals become less effective.

Lygus sprays must be timed to kill the first and second nymphal instars, if possible, because registered materials are not very effective on adults. It is important to limit the number of treatments for lygus. Insecticides applied to later nymphal stages and adults are less effective. The pyrethroid insecticides Danitol® and Brigade® have been the most effective pesticides for control of lygus bugs, but widespread resistance to these insecticides is occurring in many growing areas. They tend to be more effective when used in combination with the neonicotinoid insecticides Assail® or Actara®. The organophosphate insecticides Dibrom®, malathion, and diazinon, also used

for many years, provide only poor to fair control of lygus. Dibrom® can result in bronzing of fruit and is a concern for beneficials; if used at the end of season growers can weigh the impact of killing beneficials.

More recently, an insect growth regulator, Rimon®, has been registered that provides moderate control of lygus, but it only affects nymphs and the number of applications is limited so is probably best used against nymphs earlier in the season before populations get very high. Beleaf®, an insecticide that affects the ability of lygus to feed, is also registered and has moderate efficacy since it does not provide immediate elimination.

Today, strawberry growers struggle to control lygus because of resistance to currently registered products, and a limited number of effective products. Further, there is emerging evidence that lygus in coastal strawberry production can remain reproductive during the winter, leading to high populations for next year's crop. As lygus pest pressure increases, growers and pest control advisors are faced with working with a limited number of effective materials for lygus bug. Of the limited effective materials, efficacy of standard pesticides is lower than when they were originally registered due to the development of resistance and continued use of these products requires tank mixing to enhance efficacy.

Difficulty in controlling lygus has also changed some harvest practices. For example, one working group member explained how growers often shift from harvesting for fresh market to the processing market at the end of the season; however, some growers are foregoing sending their fruit to processing in favor of destroying their crop due to lygus infestations.

The loss of Lannate® created problems with resistance for lygus bug control. The comment was made by one working group member that there was a spike in the use of organophosphates due to the loss of Lannate®. Working group members discussed the possibility for postharvest control during the crop destruct period and recently, a Section 18 exemption for sulfloxafor (Sequoia®, Dow AgroSciences) was awarded for end-of-season applications. However, Section 18 exemptions are for one season only and are getting much more difficult to obtain. There are continued efforts to add this end-of-season application method to the full label.

Lepidopterous pests such as Beet armyworm and corn earworm can occasionally reach damaging numbers at this time of year, and their larvae may feed directly on developing flower clusters or fruit. The insect growth regulator Intrepid® and the spinosyns Radiant®, Success® and Entrust®, the insect growth regulator Rimon®, and even some *Bacillus thuringiensis* (Bt) products applied at 4- to 7-day intervals are acceptable alternatives to organophosphate and carbamate insecticides previously used during peak egg hatch. Light brown apple moth, (LBAM; *Epiphyas postvittana*) does not damage strawberry fruit, but it is a pest of concern because of its regulatory status. Chemicals used for the above mentioned lepidopterous pests are also effective for LBAM.

Western flower thrips has primarily been of concern to strawberry growers because of fruit bronzing that has been attributed to their feeding, but high thrips densities can also cause flowers and small fruit to drop. Predators such as minute pirate bugs can provide some control of thrips. The spinosyns Radiant®, Entrust® and Success® are effective against thrips, but Success® and Entrust® provide shorter residual activity than Radiant®. The number of spinosyn sprays are limited because of concerns for resistance development. Cultivars that attract high thrips populations are often bypassed by growers in favor of cultivars that are more resistant.

Whitefly control tactics that provide control when fruit is developing are virtually the same as those for the vegetative stage, but the only products with acceptable PHIs can be used once fruiting begins. In areas with perennial whitefly problems, Admire® should be applied at planting in anticipation of their occurrence. Esteem® can be used during the season (2-day restricted entry interval, or REI) and can provide excellent control. Danitol® and Brigade® in combination with malathion provide fair control of whiteflies, and these products are harsh on beneficials. Malathion alone is not effective for whiteflies, while Azatrol® (azadirachtin) provides only poor control of whiteflies.

Aphids can transmit viruses to strawberry plants, and the significance of this transmission is greatest in nurseries (to avoid infections of transplants) and during vegetative production. Honeydew secretions from aphids cause sooty mold to grow on fruit as well as leaves during this time of year, rendering the fruit unmarketable. Natural control of aphids by parasitic wasps and several other predator species can occur to a greater extent at this time of year if not disrupted by broad spectrum insecticides such as organophosphates and pyrethroids. In some circumstances, such as with the melon aphid in southern California strawberry-growing regions, the levels of biological control can be economically viable. Chemical treatments are made when natural controls have not been able to keep up with developing populations. Lorsban® and diazinon work fairly well for aphids; however, the PHIs for these products (21 days and 5 days, respectively) render them impractical to use at this time of year, and summer oils are phytotoxic during this period. Other insecticides that can be used for aphid control are mentioned in the previous section on vegetative growth.

Vinegar flies (*Drosophila* species) are more of a problem in very ripe fruit that can stay on the plant in preparation for processing (freezer and cannery). Flies tend to build up on nearby over-ripe fruit including harvested fruit left in furrows and cull piles, and then lay eggs on very ripe fruit in the field. *Drosophila suzukii*, the spotted wing drosophila, was first found in California strawberries in 2008, and this species can infest solid fruit as well as over ripe fruit. Sanitation to remove very ripe fruit and trash between rows help to limit sources of vinegar flies. Spotted wing drosophila is problematic for processing because there is a low tolerance for natural defects such as worms and larvae.

Malathion provides only poor to fair control of vinegar flies, naled, and diazinon provides fair control. Spinosyns including Radiant®, Success®, and Entrust® (registered for organic use) and pyrethroid insecticides targeting adult flies are the most effective choices, but they should be used sparingly for aphid control because of the potential for resistance development in insects of greater concern such as lygus bugs and thrips.

Working group members discussed the need for more research into biological control including predatory arthropods. There is a need to study timing, quality check lists, etc. Working group members also discussed the need for a pipeline of new products and education on proper cycling and rotation of products.

WORK GROUP RECOMMENDATIONS FOR INSECT MANAGEMENT IN CALIFORNIA STRAWBERRIES FROM FRUIT DEVELOPMENT THROUGH HARVEST

RESEARCH	• Research on improved use of predators • Evaluate new chemical controls for lygus • Evaluate cutworm controls • Evaluate whitefly controls for harvest time • Develop a resistance management strategy for spider mites • Collect quantifiable pest and damage data to support Section 18 applications during emergency pest events
REGULATORY	• Register new controls for lygus • Register whitefly materials for in-season sprays • Register alternatives to preserve efficacy of current chemical classes • Maintain current chemistries and prevent unnecessary label restrictions • Harmonize international tolerances or maximum residue levels (MRLs) to ensure no trade problems evolve with fruit destined for export markets
EDUCATION	• Educate the public and the regulatory community about the interface between urban and agricultural land • Continually emphasize proper resistance management by mixing and rotating products with different modes of action

WEEDS

Weeds are highly competitive with strawberries, but by the fruit development phase, the canopies of plants will out-compete or shade out many of the weeds (Table 10). Hand weeding around the plants and under plastic are the only way to control weeds on the top of the beds. Cultivation and contact herbicides are used to remove any remaining weeds in the furrow at this time of the season. Due to the short harvest intervals, it is imperative that any new chemical has a preharvest interval no longer than 3 days to avoid disruptions in the logistics of harvesting marketable fruit.

Table 10. Weeds of Significance to California Strawberry Production Between Fruit Development and Harvest.

Annuals:	Perennials:
Little mallow	Field bindweed
Sweet clover	Yellow nutsedge
Sunflower	
California burr clover	
Filaree	
Hairy fleabane	
Horseweed	

WORK GROUP RECOMMENDATIONS FOR WEED MANAGEMENT IN CALIFORNIA STRAWBERRIES FROM FRUIT DEVELOPMENT THROUGH HARVEST

Regulatory	Maximum of 3-day PHI needed for any new herbicide registrations
Education	Inform registrants that the maximum PHI for any new herbicide must be no greater than 3 days

DISEASES

As with foliar diseases, fruit can be infected by soilborne pathogens and/or through water that carries plant pathogens. Diseases that impact the fruit can be caused by the same organisms that caused problems earlier in the season.

The single most important disease of the fruit, Botrytis fruit rot or gray mold, is favored by cool, moist conditions. Botrytis fruit rot is the most important disease affecting fruit, both pre- and post-harvest. The spores of this pathogen are wind and splash dispersed. The pathogen infects flowers during wet or foggy weather, but the disease does not typically become apparent until the fruit ripens or after harvest. Effective control requires applications of fungicides during flowering. Since strawberry plants are continuously flowering, fungicides are typically applied on a 7- to 14-day interval throughout the long harvest period. This requires several different fungicides with different modes of action to effectively control the disease and prevent resistance development (see Appendix table 7). Resistance has been reported to FRAC Groups 1, 2, 7, 9 and 17 which contain many of the fungicides currently in use (Cosseboom et al., 2018)³. Coordination of fungicide programs is needed between nurseries and fruit production fields to maximize efficacy and minimize the development of resistance.

Common Leaf Spot

Common leaf spot, caused by *Ramularia tulasneii*, is the most important strawberry leaf spot disease worldwide, but it is rarely a commercial concern in CA. The disease can be a problem in all fruit production areas but is usually less prevalent in the drier interior valleys and southern growing regions. The use of drip irrigation can limit the onset of the disease; avoid use of overhead sprinklers. Many of the fungicides used against Botrytis fruit rot and powdery mildew are active against common leaf spot (Appendix table 7).

Other Leaf Diseases

Angular leaf spot, caused by the bacterium *Xanthomonas fragariae* and leaf blotch, caused by a fungus, *Zythia fragariae*, are common diseases seen in all growing districts and nurseries. The disease spreads via water splashing from rain or irrigation and is more prevalent in wet years. Since angular leaf spot is caused by a bacterium, copper products have been applied, but with little effectiveness. Genetic resistance has been identified for angular leaf spot, and new cultivars are being developed with this resistance (Roach et al., 2016).

Strawberry leaf blotch is often detected after heavy, prolonged rainfalls, but seldom requires fungicide applications since the disease typically is eliminated as temperatures rise and plants mature.

Viruses (mottle, crinkle, mild yellow edge, vein banding, and necrotic shock) may affect strawberry plants. Most are spread by insects, and usually more than one virus is present in a symptomatic plant. Using clean nursery stock is the primary means of excluding viruses. Vector control is only minimally effective because the diseases are usually established before control actions are taken. There are no chemical controls, and little-known vector or virus resistance.

Phytoplasmas, such as lethal decline and green petal, are transmitted by leafhoppers. As with viruses, using clean transplanting stock is the best way to exclude these diseases. Leafhopper control is only moderately effective.

Cultural controls for disease management include crop rotation and cover cropping, and these practices are particularly important for organic strawberry production. However, due to the high cost of leased land, crop rotations tend to be cost prohibitive. Working group members discussed the need to study soil microbiology so that the dynamics and epidemiology of diseases are understood. In addition, as pests increase due to the reduction of fumigation effectiveness, there is a greater need for clean nursery stock. More coordination is needed with nurseries to prevent pesticide resistance development.

Resistance management should be practiced with all fungicides. Using proper rates and rotating chemistries will help to avoid development of tolerance of and resistance to these important tools.

**WORK GROUP RECOMMENDATIONS FOR DISEASE MANAGEMENT IN CALIFORNIA
STRAWBERRIES FROM FRUIT DEVELOPMENT THROUGH HARVEST**

RESEARCH	• Identify new fungicides, especially those with kickback/curative activity on Botrytis fruit rot • Identify new fungicides that improve control of anthracnose fruit rot • Identify resistance in Botrytis and powdery mildew to commonly used fungicides
REGULATORY	• Register more than one fungicide at a time for resistance management • Work with regulators to attempt to obtain multiple Section 18s or 24-C SLNs of different chemistries for resistance management • Maximum PHI of 3 days for any new products
EDUCATION	• Educate growers on the epidemiology and control of Botrytis fruit rot and anthracnose diseases • Educate growers on best practices for resistance management

VERTEBRATE PESTS

Several species of birds (robins, goldfinches, waxwings, starlings, and curlews) and mammals can be serious pests when fruit ripens. Controls include baits, noisemakers, repellents, protective netting, trapping, and lethal control. Restrictions on lethal control vary by county.

WORK GROUP RECOMMENDATIONS FOR VERTEBRATE CONTROL IN CALIFORNIA
STRAWBERRIES FROM FRUIT DEVELOPMENT THROUGH HARVEST

NO WORK GROUP RECOMMENDATIONS WERE MADE.

POSTHARVEST

DISEASES

Postharvest disease control begins in the field, with vigorous plants and sound fruit that is free of disease organisms and physical injury. Fruit diseases are caused by pathogens that survive in soil or water; keeping fruit away from the soil and/or away from splashing water will help reduce losses.

Strawberries are harvested by hand and field-packed, without washing or hydrocooling. Thus, no postharvest treatments are applied. However, residual activity of fungicides applied in the field can provide postharvest decay control of Botrytis and Rhizopus fruit rots. Gentle handling to minimize bruising and other types of physical injury of tender fruit is critical. Within an hour or two of picking, fruit are transported to a nearby cooling facility where they are cooled, typically by forced air to 34° F. Rapid cooling reduces decay and prolongs fruit shelf-life.

A few controlled atmosphere treatments (e.g., TransFresh/Tectrol®) are used to extend shelf life, partially through suppression of disease development during transit. Because of cost, these treatments are typically reserved for long-distance transport (to the east coast of the United States or overseas for export).

Nearly all strawberry fruit is shipped to market in refrigerated trucks, kept at 32° F. The typical timeline from harvest to delivery destinations is shown in Table 11.

Table 11. Harvest to Delivery Timelines for California Strawberries.

TIME	DAY 1: HARVEST	DAYS 2- 6: SHIPPING WITHIN U.S.	RECEIVING DOCK TO U.S. MARKET	DAYS 2- 6: SHIPPING OUTSIDE U.S.
ACTIVITIES	Delivery to yard and cooling: 1-4 hours	To Seattle: 1 day To Denver: 2 days To Chicago: 3 days To NY/Boston: 4 days	1 day	Canada: 3-5 days Mexico: 3-5 days Japan (air freight): 1 day

Botrytis fruit rot is the most common and serious postharvest disease of strawberries due to its ability to grow at the temperatures in which fruit are stored. Infection by this organism, and several other

pathogens, usually begins early in the season, but is not expressed until the fruit has been harvested or held in storage. Individual fruit can be lost in the field, but decay after harvest may spread rapidly to other fruit in packages (nesting), leading to the entire loss of the harvested and stored product that is destined for the retail market.

Removing overripe fruit during harvest and discarding all berries with any sign of decay while packing will help to reduce loss potential. Prompt cooling after picking, and maintenance of proper storage temperatures under controlled atmospheric conditions, will also reduce Botrytis fruit rot. Most fungicides will protect fruit for 5 to 7 days and depending on the timing of application in relation to harvest, may provide some level of postharvest disease control.

Rhizopus rot and Mucor fruit rot are caused by ubiquitous organisms spread by wind and insects; infection occurs only through wounds in ripe fruit. This disease is managed mainly by using plastic mulch to limit fruit contact with infected soil and plant debris. Rhizopus rot (but not Mucor) can be minimized by providing prompt cooling after picking and maintaining proper storage temperatures.

Pre-shipment fumigations are required by Japan; in addition, other countries have general fumigation requirements for insects and diseases which must be adhered to or loads will be rejected.

INSECTS

Vinegar fruit flies are considered a pest of processed fruit because they lay eggs in fruit that can fully ripen in the field before being harvested for the freezer or canning industry. The best control for this pest is good sanitation practices both in the field and around fruit processing areas to reduce vinegar fruit fly populations. If an insecticide is used, a spinosyn insecticide such as Radiant®, Success® or Entrust®, organophosphates such as malathion or diazinon, or insecticides containing pyrethrum (such as Pyganic®) can be applied to reduce adults that could oviposition in the processing fruit.

WORK GROUP RECOMMENDATIONS FOR POSTHARVEST INSECT AND DISEASE MANAGEMENT

Research	• Develop improved methods to package and monitor the cold chain when moving fruit to market
----------	--

STRAWBERRY INDUSTRY CONCERNS

LABOR AND INFLUENCE ON PEST MANAGEMENT

Integrated pest management in strawberries relies heavily on laborers for hand weeding, transplanting, runner cutting, irrigation, equipment operation, transportation and harvesting. Labor shortages can highly impact weeding (approximately 40% of pest management costs in 2015/2016), field sanitation, trained applicators and harvest. Lack of labor for harvest can result in sanitation issues (i.e., fruit rotting between rows) which can lead to increased pest problems.

Labor Shortages Annual crop loss due to lack of labor is estimated at \$100,000,000 annually in California strawberry production. In recent years, the strawberry industry has experienced a 20% labor shortage and has been forced to utilize the H-2A temporary guest worker program. In southern California, growers are extending their H-2A contracts to allow harvesters to also pick for processing through the 3rd week in June. In all regions, competing crops often influence labor availability.

Reduced Hours – Based on agriculture's (previous) 60-hour work week, the strawberry industry needed 1.5 workers per acre or 55,500 workers. As the result of AB 1066 (2016 state legislation), the 60-hour work week is being reduced to a 40-hour work week (full phase in expected in 2025). As a result, the industry will need 2.25 workers per acre, or 83,250 workers to maintain production.

Increases to Cost of Labor – The State Legislature passed SB 3 which, when fully phased in (2023), increases the minimum wage from \$10 per hour to \$15 per hour tied to inflation.

Paid Sick Leave – California's Paid Sick Leave law (AB 1522) has complicated the industry's ability to properly staff operations due to spikes in use of sick time during peak season when paid leave is most lucrative to employees.

NEW PRODUCTS

Working group members shared concerns with consolidation of registrants. The cost to bring a new chemical to market is estimated by the group to be about \$300 million. Working group members are concerned that mergers will result in a decrease of new products and may impact the availability of different modes of action. Working group members questioned whether merged companies will keep competing modes of action for controlling the same pest? Eventually there could be less diversity among products.

Another issue is that registrants may be reluctant to register products on smaller crops such as strawberries because the volume of pesticide sales for the crop is relatively small versus the impact of the dietary exposure of the crop on the "risk cup" (FQPA). Despite these concerns, new product development must continue, and industry should consider a method for identifying new active ingredients (as they are registered for other crops) and assess their potential for use in strawberries. Ingredients identified with the potential to benefit strawberries could then be pursued by working with the registrants, perhaps enlisting the support of IR-4 for tolerance development, and working through the regulatory process

However, in California, the registration process for new active ingredients, especially for new fumigants, has become extremely slow, due to several social and political factors. As this plan update illustrates, the development of pest resistance to numerous chemistries is occurring at the same time that the registration process is slowing down. This has caused a greater need for alternate pathways to obtain new uses for pesticides that are currently registered but don't have strawberries on the label (Section 24 C Special Local Need Registrations or SLNs) and for short term Emergency Exemptions from Registration (Section 18 Emergency Exemption). While these pathways are critical to combat resistance, as the pest resistance is building up faster than new products can be registered, the data required to support these actions are now so extensive that they can hardly be accomplished in time to deal with a true emergency.

Regulators must verify that a special local need or an emergency need exists – that currently registered products cannot control the target pest well enough to prevent serious economic damage. Ongoing data and production statistics are key to securing an SLN or a Section 18. Regulators want to see real numbers (not extrapolations) for individual farms (not industry wide data). Consequently, the burden falls on the industry to create a process to collect data on an on-going basis to support the loss of efficacy of existing products.

Workgroups have identified the need for additional materials for various weeds, pests and diseases, including, but not limited to, lygus, mites, thrips, Botrytis fruit rot, powdery mildew, other postharvest diseases, Verticillium wilt, Fusarium wilt, and Macrophomina crown rot. Growers expressed a need to have a radar to see what products are being registered on other crops, with the goal of identifying chemistries which strawberries could pursue.

With the prospects for getting new products registered in a timely manner diminishing, getting the most out of existing products is imperative. This means combating pest resistance through adherence to resistance management strategies from the nursery through all production stages. Growers, and PCAs must be well trained in these programs and follow them carefully. Regulators must be aware of the importance of maintaining the use of multiple modes of action and how the decisions they make affect the long-term utility of crop protection tools and the maintenance of integrated pest management programs.

REGULATORY RESTRICTIONS

Advocacy groups with a goal of reducing pesticide use have become more active in lobbying the California legislature and state and federal regulatory agencies, at times theorizing risk scenarios that have little scientific basis, but high emotional appeal. Pressure from these sources has led to legislative proposals as well as court actions affecting the pesticide regulatory program.

Misperception of risk by the public and inadequate risk communication by public agencies and institutions has increased public pressure on regulators to create restrictions on pesticide use beyond what scientific knowledge supports. Consequently, in recent years, regulatory restrictions have placed more and more limitations on the use of crop protection tools.

Water Regulations: While US EPA and DPR have the legal responsibility to regulate pesticide use, some California regional water boards are exercising their authority to regulate water quality

through discharge requirements that impact pesticide use. Detection of organophosphates and pyrethroids in runoff has resulted in grower waste discharge management plans which discourage use of these active ingredients, further reducing the tools available to manage pests and combat resistance.

Agriculture/Urban Interface: Growers are impacted more than ever by regulatory action because of urban sprawl. A special problem is the siting of schools on the outskirts of communities in ag lands resulting in new requirements for those growing in proximity to schools.

Crop Protection Tools: Industry has experienced loss of some tools and have had to comply with a host of new restrictions and mitigations. Perhaps the most significant restriction impacting strawberry growers is the loss of methyl bromide as 2016 represented the final year in which a Critical Use Exemption under the Montreal Protocol was available for pre-plant soil use in California strawberries. The phase out of methyl bromide has resulted in an emergence of soilborne diseases –including Verticillium wilt, Fusarium wilt, and Macrophomina crown rot.

In 2015, DPR announced new mitigation measures for the use of chloropicrin products. Mitigation measures made changes to buffer zones, buffer zone credits, approved tarps, and emergency preparedness procedures.

Some counties impose even more restrictive requirements. For example, as part of their mitigation measures for the use of soil fumigant products containing chloropicrin, DPR announced a new California-specific list of tarps eligible for reduced buffer zones. This list contains fewer tarps than the U.S. EPA's 60% buffer zone credit list, because DPR has a different, and more conservative, set of permeability testing conditions. Some coastal counties require those tarps be used for all applications of chloropicrin.

DPR's 2016 regulatory decision regarding use restrictions for 1,3-D limits growers to 136,000 lb per township (36 square miles) per calendar year. In addition, banking, which allowed the carryover of authorized, but unused pounds from one year to the next, was discontinued. Furthermore, applications of 1,3-D are prohibited statewide for the month of December, as wind conditions tend to be more stagnant, resulting in less air mixing and slower dilution of fugitive emissions. Finally, DPR is in the process of preparing a new 1,3-D Risk Management Directive and eventual Rulemaking to address acute and cancer risk mitigation. The scope of this new rulemaking is unknown at the time of this publication.

Insecticides: Federal and state regulators appear to be headed toward reducing the use of neonicotinoids that may affect pollinators, regardless of whether pollinators are required or used to produce a crop. California strawberry production does not rely on bees for pollination and bees don't prefer to forage on strawberries. However, potential restrictions are a real threat to strawberry pest management as certain neonicotinoids have a role in control of aphid, lygus, and whiteflies when needed. Currently, DPR is developing label mitigation on a crop-by-crop basis as a result of their recent Neonics Pollinator Risk Determination document. For this reason, there is a need for the California strawberry industry to document actual use patterns of neonicotinoid use, so that DPR can adjust their assumption that all materials are used at the maximum rate, and with the maximum allowed number of applications.

Further, EPA is currently conducting a registration review of pyrethroids which assist in controlling a variety of common pests in strawberry production, including a significant role in the control of lygus. While not completed, it appears that EPA label amendments will recognize the lower risk of runoff of pyrethroids in the arid West. Nevertheless, continued scrutiny by California's Regional Water Boards may lead to additional requirements when pyrethroids are applied to assure they don't end up at toxic levels in waterways.

IR-4 SYSTEM PROJECT PRIORITIES

The IR-4 research and registration process will become increasingly important as new products are required to replace crop protection tools. The strawberry industry participation at IR-4 meetings should be encouraged to have a university liaison active in IR-4 activities and present at each annual IR-4 Food Use Workshop.

INTERNATIONAL TRADE/CODEX

Trade must not be hampered by regulatory differences between exporting and importing countries. As new products are registered in the United States, commodity groups and US EPA must work to ensure that all pesticides used on California strawberries are acceptable to importing countries.

Complicating internationally recognized Maximum Residue Limits (MRL) is the trend of countries who have developed and maintain their own national lists. Some countries have default and/or deferral procedures which allow them to use Codex under certain circumstances, but there are many markets which do not defer or default. The result can be an MRL of 0.00.

Growers discussed how they have different pesticide application programs dependent on their intended destination country; this is due to lack of MRLs to or deferral and default policies in export countries.

WORK GROUP RECOMMENDATIONS FOR INTERNATIONAL TRADE/CODEX CONCERNS

REGULATORY	• Work with the registrant community, USDA, EPA and the California Strawberry Commission to ensure maximum residue levels (MRLs) are in place for products in the registration process at US EPA • Determine the international MRL status of any new products • Appoint university liaison for IR-4 activities, including attendance at the annual Food Use Workshop
-------------------	--

CONSUMER PERCEPTION

With social media and negative campaigns such as the "Dirty Dozen" list, there is a misperception about what is safe.

Consumer perception and NGO-driven "no use" pesticide lists have resulted in retailers dictating acceptable chemistries. Neonicotinoids and organophosphates are already being targeted. Pressure generated by various advocacy groups also tends to slow down the federal and state

registration processes and discourage registrants from entering the California market, especially for specialty crop products.

All of this can create problems for the maintenance and further development of integrated pest management strategies, if key chemical components of the system can no longer be used. The same is true of resistance management programs where the rotation of multiple chemistries is necessary.

WORKER PROTECTION

As products move through the U.S. EPA registration and re-registration phases, attention to occupational risk will increase. Considerable hand and field labor are required to produce and harvest strawberries. It is therefore critical to identify products and practices that may be of concern to regulators and to suggest appropriate risk mitigation practices. Descriptions of worker activities are provided in Appendix 3.

WORK GROUP RECOMMENDATIONS FOR WORKER PROTECTION

KEY WORKER RISK ISSUES	• Provide accurate data to U.S. EPA on worker exposures, time performing activities, etc. for risk assessments • Educate growers and workers on techniques, equipment, and personal protective equipment (PPE) for alternatives to methyl bromide and/or other fumigants
REGULATORY ACTIONS AND ISSUES	• Ensure all necessary testing is done to establish appropriate REIs and PHIs
EDUCATIONAL ISSUES	• Educate public/legislators on need for hand weeding in strawberries

FOOD SAFETY

Strawberries must be free of any micro-organisms that cause human illness. Pathogens of concern in strawberries include *E. coli*, *Salmonella*, *Listeria*, and *Cyclospora*. Protecting the safety of California strawberries requires a comprehensive and coordinated effort throughout the entire food production and transportation system. The responsibility to safeguard the fruit is shared among the growers, farm workers, packers, shippers, transporters, importers, wholesalers, retailers, government agencies, and consumers.

Contamination by these organisms occurs mainly through water (in the field or packing house), through exposure to manure or municipal bio-solids, through inadequate worker hygiene, and through poor sanitary conditions at packing facilities and in transport. Growers, packers, and shippers should consider the physical characteristics of the produce and the potential sources of microbial contamination associated with their operations and determine which combination of good agricultural and management practices limits contamination most cost effectively.

The California Strawberry Commission was one of the first to develop a comprehensive food safety program. California strawberry growers serve as the model for other produce commodities and continually seek to improve practices to deliver healthful, safe strawberries to market. These efforts

were recognized in 2010 with the prestigious NSF International Food Safety Award. In 2012, the California Strawberry Commission launched its Food Safety Certificate Program. Designed for strawberry growers, ranch managers, field supervisors or any other farm-level employee with food safety responsibilities. The program teaches key food safety practices necessary to minimize the risk of microbial contamination of strawberry fruit during harvest.

In 2011, Congress enacted the Food Safety Modernization Act (FSMA) which represented the first real update to the Nation's food safety laws since 1938. The law is aimed at shifting from response to prevention. Major elements of the FSMA can be divided into five key areas: 1) preventive controls, 2) inspection and compliance, 3) imported food safety, 4) response, and 5) enhanced partnerships.

FDA is implementing the FSMA through seven foundational rules, including a Produce Safety rule that establishes science-based standards for growing, harvesting, packing and holding produce on domestic and foreign farms.

WORK GROUP RECOMMENDATIONS FOR FOOD SAFETY

RESEARCH	• Determine the post-freezing survival of pathogens in soil, on fruit, and in storage • Determine the risk of contamination from compost
REGULATORY	• Keep the industry's quality assurance programs self-enforcing
EDUCATION	• Promote adoption of Good Agricultural Practices (GAP) • Provide training on personal hygiene and sanitation to growers, nurseries, field workers, and processing plant workers

IMPACT OF WEATHER, DROUGHT, AND IRRIGATION

In Oxnard, discussion occurred on the explosion of pest populations, such as the twospotted spider mite, due to drought.

In Oxnard, the comment was made that growers are using more and more micro sprinklers. This is due in part to water regulations. Seeking a move from rain birds to micro sprinklers: It is estimated that 60 percent of conventional fields now have micro sprinklers and 80 percent are on target to have them. Micro sprinklers have the benefit of suppressing spider mites and *P. persimilis* if used correctly. However, micro sprinklers may increase powdery mildew unless sulfur is applied.

Another comment made about plant establishment and leaching salt in systems dominated by micro sprinklers. A great deal of research has been conducted on this topic in other cropping systems. The strawberry industry may need more information.

The use of hoops is sometimes used for protection from rain (not used to accelerate growth). Powdery mildew is favored by conditions in hoops (reduced UV and high humidity).

CRITICAL ISSUES FOR THE CALIFORNIA STRAWBERRY INDUSTRY

The following areas were identified by strawberry workgroup participants as most critical to the sustained viability of the California strawberry industry.

RESEARCH	• Develop new methods to produce clean nursery stock • Conduct long-term research on fumigation alternatives in high and low elevation nurseries • Develop information on soil microbiome and microbiology to determine epidemiology of soilborne diseases • Evaluate fumigation alternatives to methyl bromide and conduct long-term research in production fields • Evaluate new materials for in-season whitefly control • Evaluate new materials and techniques to manage lygus bugs • Develop a resistance management strategy for mites • Develop and evaluate herbicides for use under plastic mulches and in furrows • Evaluate new materials for control of powdery mildew • Determine fungicide resistance in powdery mildew populations • Conduct research on the biology and epidemiology of anthracnose • Conduct research on effective cultural practices and materials to combat soilborne diseases • Develop improved pest management and crop production methodologies for organic growers • Conduct research on improvement of strawberry cultivars through breeding to improve horticultural and pest resistance for organic and conventional production systems • Conduct research on pest management in benchtop/greenhouse production • Conduct research in labor saving automation • Develop pest management programs that incorporate nurseries and fruit grower practices to improve efficacy and reduce resistance development
REGULATORY	• Correct information on pollinators which regulators use to make decisions • Register methyl bromide alternative fumigant chemistries (e.g., Dominus®) • Retain methyl bromide for nursery production under Montreal Protocol QPS exemption • Work with California DPR as it develops new label language to mitigate acute and long-term exposures to 1,3-D fumigant • Harmonize international tolerances and MRLs • Encourage more consistent interpretation of label requirements and regulations by County Ag Commissioners • Encourage as much uniformity as possible in county permit requirements • Reduce carbaryl bait PHI • Register materials for lygus, whiteflies, thrips and powdery mildew • Seek Section 18 (post-harvest-crop destruct) for Methomyl for lygus

	• Register organophosphate and carbamate alternatives as soon as possible; utilize the IR-4 priority system for research on reduced risk materials • Harmonize CalEPA and U.S. EPA registrations to hasten new product registrations • Register more than one fungicide or new mode of action at a time for resistance management • Work with regulators to attempt to obtain Special Local Need registrations of different modes of action for resistance management • Seek PHIs of 3 days maximum • Develop best management practices (BMPs) and environmental mitigation measures for environmental issues • Identify potential trade irritants as early as possible in the research and registration process; insure there are no conflicts with provisions of the United States-Mexico-Canada Agreement or Codex • Ensure access to a stable and reliable labor supply
EDUCATION	• Educate growers and PCAs on fumigant alternatives • Educate the public and regulators on the need for fungicides • Educate growers, PCAs, and regulators on resistance management • Educate regulators about the absence of pollinators in strawberry production • Educate regulators on systems approaches to using fumigants • Educate applicators and growers on safe and efficient application techniques • Educate growers, PCAs, and commodity members on the use of best management practices (BMPs) to protect and improve water and soil quality • Work with nurseries to provide information and communication regarding plant quality and feedback from growers • Facilitate communication and coordination between nurseries and growers on resistance issues for active ingredients used by both

REFERENCES AND RESOURCES

Publications

California Department of Food and Agriculture. 2018a. California Agricultural Statistics Review. <https://www.cdfa.ca.gov/statistics/>

California Department of Food and Agriculture. 2018b. California Agricultural Exports. <https://www.cdfa.ca.gov/statistics/PDFs/2017-18AgExports.pdf>

California Department of Pesticide Registration. 2018. Summary of Pesticide Use Report Data, 2016. <https://www.cdpr.ca.gov/docs/pur/pur16rep/comrpt16.pdf>.

California Strawberry Commission. 2018. California Strawberry Farming. <http://www.calstrawberry.com/Portals/2/Reports/Industry%20Reports/Industry%20Fact%20Sheets/California%20Strawberry%20Farming%20Fact%20Sheet%202018.pdf?ver=2018-03-08-115600-790>.

California Strawberry Commission. 2019a. Export Data. <http://www.calstrawberry.com/en-us/market-data/california-exports>

California Strawberry Commission. 2019b. Volume Pink Sheet. <https://www.calstrawberry.com/es-us/market-data/volume-pink-sheet-report>

California Strawberry Commission. 2019c. Acreage Survey. <http://www.calstrawberry.com/en-us/Market-Data/Acreage-Survey>

Cosseboom, S.D., K.L. Ivors, G. Schnabel, P.K. Bryson, and G.J. Holmes. 2019. Within-Season Shift in Fungicide Resistance Profiles of *Botrytis cinerea* in California Strawberry Fields. Plant Disease 103:59-64. <https://doi.org/10.1094/PDIS-03-18-0406-RE>

de Ponti, T., B. Rijk and M. K. van Ittersum. 2012. The crop yield gap between organic and conventional agriculture. Agricultural Systems 108:1-9. <https://www.sciencedirect.com/science/article/pii/S0308521X1100182X>.

Environmental Protection Agency. 2015. Protection of Stratospheric Ozone: The 2016 Critical Use Exemption from the Phaseout of Methyl Bromide. <https://www.federalregister.gov/articles/2015/10/15/2015-26301/protection-of-stratospheric-ozone-the-2016-critical-use-exemption-from-the-phaseout-of-methyl>

Forcelini, B. B., T. E. Seijo, A. Amiri, and N. A. Peres. 2016. Resistance in Strawberry Isolates of *Colletotrichum acutatum* from Florida to Quinone-Outside Inhibitor Fungicides. Plant Disease 100:2050-2056. <https://doi.org/10.1094/PDIS-01-16-0118-RE>

Food and Agriculture Organization. 1999. Annex 1. Crop Salt Tolerance Data.
<http://www.fao.org/docrep/005/Y4263E/y4263e0e.htm>

Foulis, E.S.J. and D. Goulson. 2014. Commercial bumble bees on soft fruit farms collect pollen mainly from wildflowers rather than the target crops. *Journal of Apicultural Research* 53:404-407.
<https://doi.org/10.3896/IBRA.1.53.3.08>

Adaskaveg, J. E., D. Gubler, T. Michailides. 2017. Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut, Strawberry, and Vine Crops 2017. University of California Statewide IPM Program.
<http://www.ipm.ucdavis.edu/PDF/PMG/fungicideefficacytiming.pdf>

Holmes, G.J., S. M. Mansouripour, and S. Hewavitharana. 2020. Strawberries at the crossroads: Management of soilborne diseases in California without methyl bromide. *Phytopathology* 110:956-968.
<https://doi.org/10.1094/PHYTO-11-19-0406-IA>

Geisseler, D. and W. R. Horwath, 2014. Strawberry Production in California.
http://apps.cdfa.ca.gov/frep/docs/Strawberry_Production_CA.pdf

Klonsky, K. 2011. Comparison of Production Costs and Resource Use for Organic and Conventional Production Systems. *Amer. J. Agric. Econ.*
<https://academic.oup.com/ajae/article/94/2/314/58471>.

López-Aranda, J. M., F. Romero, F. Montes, J. J. Medina, L. Miranda, B. de los Santos, J. M. Vega, J. I. Páez, R. Dominguez, J. López-Medina and F. Flores. 2001. Chemical and Non-Chemical Alternatives to MB Fumigation of Soil for Strawberry. 2000-2001 Results. Methyl Bromide Alternatives Outreach Conference, 2001, San Diego, California.
<https://mbao.org/static/docs/confs/2001-sandiego/papers/040%20Lopez-Aranda%20JM%20Strawberry%20Huelva%202001San%20Diego%201.pdf>

Mazzola, M., J. Muramoto, and C. Shennan. 2018. Anaerobic disinfestation induced changes to the soil microbiome, disease incidence and strawberry fruit yields in California field trials. *Applied Soil Ecology* 127:74-86.
<https://doi.org/10.1016/j.apsoil.2018.03.009>

Postharvest Technology of Horticultural Crops, Second Edition, 1992, UC ANR Publication 3311.

Roach, J.A., S. Verma, N.A. Peres, A.R. Jamieson, W.E. van de Weg, M.C.A.M. Bink, N.V. Bassil, S. Lee, and V.M. Whitaker. 2016. *FaRXf1*: a locus conferring resistance to angular leaf spot caused by *Xanthomonas fragariae* in octoploid strawberry. *Theor. Appl. Genet.* 129:1191-1201.
<https://doi.org/10.1007/s00122-016-2695-1>

Shennan, C., J. Muramoto, S. Fennimore, M. Mazzola, and G. Lazarovits. 2012. Non-fumigant strategies for soilborne disease control in California strawberry production systems. California Strawberry Commission Annual Production Report. 2012:145-159. <https://bit.ly/2RDEwfa>.

Shennan, C., J. Muramoto, S. Koike, G. Baird, S. Fennimore, J. Samtani, M. Bolda, S. Dara, O. Daugovish, G. Lazarovits, D. Butler, E. Roskopf, N. Kokalis-Burelle, K. Klonsky, and M. Mazzola. 2018. Anaerobic soil disinfestation is an alternative to soil fumigation for control of some soilborne pathogens in strawberry production. *Plant Pathology* 67:51-66. <https://doi.org/10.1111/ppa.12721>

Sombardier, A., M.-C. Dufour, D. Blancard, and M.-F. Corio-Costet. 2010. Sensitivity of *Podosphaera aphanis* isolates to DMI fungicides: distribution and reduced cross-sensitivity. *Pest Management Science* 66:35-43. <https://doi.org/10.1002/ps.1827>

Strand, L. L. 2008. Integrated Pest Management for Strawberries, 2nd Edition. University of California ANR Publication 3351.

Strawberry Production Manual, For Growers on the Central Coast, 2015, <http://cesantabarbara.ucanr.edu/files/228579.pdf>.

University of California, Agriculture and Natural Resources. 2019. Integrated Pest Management for Strawberries. <https://www2.ipm.ucanr.edu/agriculture/strawberry/>

Van Leeuwen, T., J. Vontas, A. Tsagkarakou, W. Dermauw, and L. Tirry. 2010. Acaricide resistance mechanisms in the two-spotted spider mite *Tetranychus urticae* and other important Acari: A review. *Insect Biochemistry and Molecular Biology* 40:563-572. <http://doi.org/10.1016/j.ibmb.2010.05.008>

Websites

California Strawberry Commission, <http://www.calstrawberry.com/en-us/>

California Department of Pesticide Regulation, Pesticide Use Reports, 1989 – 2016, <https://www.cdpr.ca.gov/docs/pur/purmain.htm>

Cal Poly Strawberry Center, <https://strawberry.calpoly.edu/>

Inter-regional Research Project #4, <https://www.ir4project.org/>

A Pest Management Strategic Plan for Strawberry Production in California. 2003. <https://ipmdata.ipmcenters.org/documents/pmsps/CASTRAWBERRY.PDF>

United States Department of Agriculture, National Agricultural Statistics Service, California, [http://www.nass.usda.gov/Statistics by State/California/](http://www.nass.usda.gov/Statistics_by_State/California/)

University of California, Integrated Pest Management Guidelines: Strawberry, <https://www2.ipm.ucanr.edu/agriculture/strawberry/>

Western Regional Pest Management Center website
<http://www.wrpmc.ucdavis.edu/index.html>

APPENDICES

1. LAND PREPARATION, CULTURAL PRACTICES, PEST MANAGEMENT ACTIVITIES AND NURSERY PLANTING AND HARVESTING IN CALIFORNIA

- A. OXNARD PRODUCTION REGION
- B. SANTA MARIA PRODUCTION REGION
- C. WATSONVILLE/SALINAS PRODUCTION REGION

2A. DESCRIPTION OF CULTURAL PRACTICES, 2016

2B. DESCRIPTION OF PEST MANAGEMENT ACTIVITIES, 2016

3. SEASONAL PEST OCCURRENCE IN CALIFORNIA STRAWBERRIES

- A. ORANGE COUNTY/SAN DIEGO PRODUCTION REGION
- B. OXNARD PRODUCTION REGION
- C. SANTA MARIA PRODUCTION REGION
- D. WATSONVILLE PRODUCTION REGION

4. EFFICACY OF INSECT MANAGEMENT TOOLS USED IN CALIFORNIA STRAWBERRIES

- A. PRIMARY INSECTS – REGISTERED AND UN-REGISTERED CHEMICAL PRODUCTS
- B. SECONDARY INSECTS – REGISTERED AND UN-REGISTERED CHEMICAL PRODUCTS

5. RELATIVE TOXICITY OF INSECT MANAGEMENT TOOLS TO BENEFICIAL ORGANISMS IN CALIFORNIA STRAWBERRIES

6. EFFICACY OF WEED MANAGEMENT TOOLS USED IN CALIFORNIA STRAWBERRIES

7. EFFICACY OF DISEASE MANAGEMENT TOOLS USED IN CALIFORNIA STRAWBERRIES

8. EFFICACY OF VERTIBRATE PEST MANAGEMENT TOOLS USED IN CALIFORNIA STRAWBERRIES

9. CHEMICAL USE ON CALIFORNIA STRAWBERRIES 2013-2016

10. MAXIMUM RESIDUE LEVELS FOR STRAWBERRIES

11. MEMBERS OF THE CALIFORNIA STRAWBERRY WORK GROUP

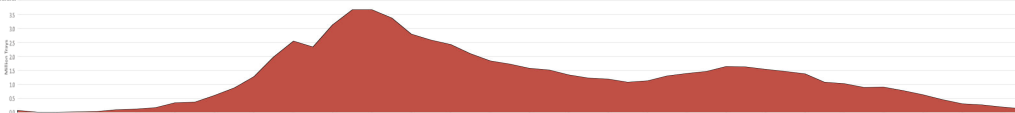
a. Oxnard Production Region

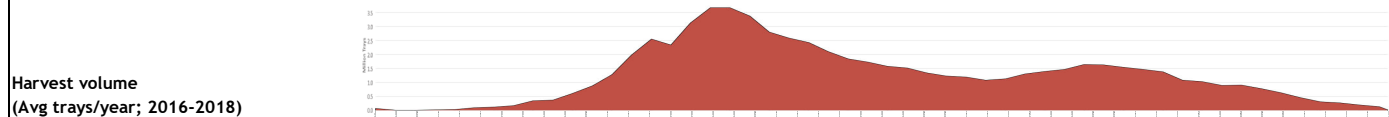
Key to abbreviations
S = Summer planted crop; s = ramping up/down
F = Fall planted crop; f = ramping up/down
P = Planting in nurseries
H = Harvest/digging plants in nurseries

Footers
z = ground preparation includes ripping, plowing, disking, leveling and other operations to prepare soil for listing.
y = flat fumigation occurs prior to listing; generally not practiced for summer planting.
x = bedding up includes bed formation, drip irrigation tape installation, preplant fertilizer application and plastic mulch laying.
w = bed fumigation occurs after bedding up.
v = Frost protection utilizes mostly overhead irrigation and wind machines
u = bloom removal not practiced in Oxnard due to need for early fruit.
t = vertebrate pest management includes rodents (mice, voles, gophers, ground squirrels), rabbits, deer and birds.
s = early harvest is used for earliest planting in Baja California and Oxnard

APPENDIX 1. Land Preparation, Cultural Practices, Pest Management Activities and Nursery Planting and Harvesting in California Strawberries

b. Santa Maria Production Region

Nursery Planting & Harvesting	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec																							
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4																												
Low elevation (Turlock, Manteca)	H	H	H	H												P	P	P	P																													H																				
High elevation (Macdoel)													P	P	P	P																																																				
Land Preparation	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec																							
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4																								
Soil analysis													S	S	S	S	S	S	S	S									f	f	F	F	F	F	F	F	F	F	F																													
Water analysis*													S	S	S	S	S	S	S	S									f	f	F	F	F	F	F	F	F	F	F																													
Ground preparation ^z								s	s	S	S	S	S	S	S	S	S											f	f	F	F	F	F	F	F	F	F	F	F																													
Pre-bedding sprinkler irrigation													S	S	S	S												F	F	F	F	F	f	f	f																																	
Fumigation flat ^y													S	S	S	S	S	S											F	F	F	F	F	F																																		
Fumigation in bed ^x														S	S	S	S	S	S	s										F	F	F	F	F																																		
Listing / bedding-up ^w														S	S	S	S	S	S	S										F	F	F	F	F	F	F	F	F	F	F	f	f																										
Cultural Practices	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec																							
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4																								
Transplanting																				s	S	S	S	S	s												f	f	F	F	F	F	f	f																								
Post-plant irrigation - overhead (stand est.)																				s	S	S	S	S	S	S	S	s								f	f	F	F	F	F	F	F	F	F	F	f																					
Frost protection ^v																																																																				
Cutting runners													f	F	F	F	F	F	F	F	F	F	F	F	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF																		
Drip irrigation	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	sF	sF	sF	sF	F	F	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF																		
Cultivation					F	F	F	F	f	f			f	f	f	f	f	f	f	f	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F																			
Cultivation - organic	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	sF	sF	sF	sF	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF																	
Bloom removal ^u	F	F	F	F	f	f	f																					S	S	S	S																																					
Flowering and fruit development	sF	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	sF	sF	sF	sF	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S																		
Harvest					f	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	sF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF																
Processing																														f	f	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F															
Fertilizer applications	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	sF	sF	sF	sF	F	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF																
																																																																				
Harvest volume (Avg trays/year; 2016-2018)																																																																				
Pest Management Activities	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec																							
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4																								
Scouting	B																																								E																											
Soil Fumigation (see above Land Prep.)																																																																				
Insecticide applications (1X/1-4wk)	f	f	f	f	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	Sf	Sf	S	S	S	S	S	S	sF	sF	sF	sF																						
Predatory mites release (1-4X/season; 1X/mo.)	F	F	F	F	F	F	F	F	F	F	F	f					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S																				
Bug vacuuming for lygus (2X/wk)	f	f	f	f	f	f	f	f	f	f	f	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f																				
Fungicide applications (1X/2wk)	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f							F	F	F	F																				
Herbicide applications - preplant													S	S																		F	F	F																																		
Hand weeding (1X/6wk; season long maint)	F	F	F	F	F	F	F	F	F	F	F	F	F	F																																F	F	F	F	F	F	F	F	F														
Hand weeding - organic (1X/3-4wk; season long)	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF																			
Vertebrate pest management ^t	SF	SF	SF	SF	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF																		



Pest Management Activities	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec								
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4													
Scouting																																	B								E												
Soil Fumigation (see above Land Prep.)																																																					
Insecticide applications (1X/1-4wk)	f	f	f	f	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	sF	S	S	S	S	S	sF	sF	sF	sF											
Predatory mites release (1-4X/season; 1X/mo.)	F	F	F	F	F	F	F	F	F	F	f	f									S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	f	f	f	f	f	f	f										
Bug vacuuming for lygus (2X/wk)	f	f	f	f	f	f	f	f	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	f	f																					
Fungicide applications (1X/2wk)	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f								F	F	F	F							
Herbicide applications - preplant													S	S	S																	F	F	F																			
Hand weeding (1X/6wk; season long maint)	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF							
Hand weeding - organic (1X/3-4wk; season long)	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF					
Vertebrate pest management ^t	SF	SF	SF	SF	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF					

Key to abbreviations

S = Summer planted crop; s = ramping up/down

F = Fall planted crop; f = ramping up/down

P = Planting in nurseries

H = Harvest/digging plants in nurseries

Footers

z = ground preparation includes ripping, plowing, disking, leveling and other operations to prepare soil for listing.

y = flat fumigation occurs prior to listing; generally not practiced for summer planting.

x = bedding up includes bed formation, drip irrigation tape installation, preplant fertilizer application and plastic mulch laying.

w = bed fumigation occurs after bedding up.

v = Frost protection not practiced in Santa Maria.

u = bloom removal is used to promote vegetative growth, thus delaying and improving first harvest volume and quality; very rain and frost dependent

t = vertebrate pest management includes rodents (mice, voles, gophers, ground squirrels), rabbits, deer and birds. Birds are season-long problem for ALL growers; rodents are localized

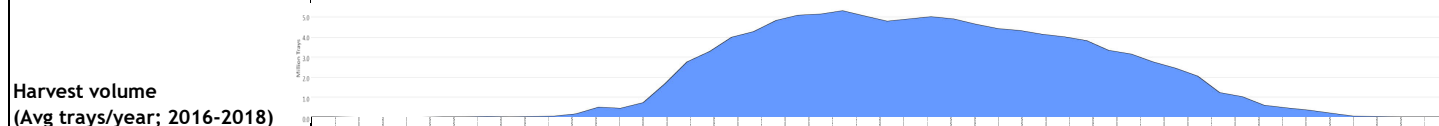
s = early harvest is used for earliest planting in Baja California and Oxnard

* monthly water testing during harvest months for food safety

fungicide applications for Botrytis; commonly preplant dip treatments are applied for anthracnose

APPENDIX 1. Land Preparation, Cultural Practices, Pest Management Activities and Nursery Planting and Harvesting in California Strawberries
c. Watsonville/Salinas Production Region

Nursery Planting & Harvesting	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4				
Low elevation (Turlock, Manteca)	H	H	H	H												P	P	P	P																												H	
High elevation (Madoel)												P	P	P	P	P																																
Land Preparation	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Soil analysis																																																
Water analysis																																																
Ground preparation ^z																																																
Pre-bedding sprinkler irrigation																																																
Fumigation flat ^y																																																
Fumigation in bed ^x																																																
Listing / bedding-up ^w																																																
Cultural Practices	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Transplanting																																																
Post-plant irrigation - overhead																																																
Frost protection ^v																																																
Cutting runners (1-2X/wk)																																																
Drip irrigation																																																
Cultivation																																																
Cultivation - organic																																																
Bloom removal (1X) ^u																																																
Flowering and fruit development																																																
Harvest																																																
Processing																																																
Fertilizer applications																																																
																																																
Harvest volume (Avg trays/year; 2016-2018)																																																
Pest Management Activities	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Scouting																																																
Soil Fumigation (see above Land Prep.)																																																
Insecticide applications (1X/2-4wk)																																																
Predatory mites release (1-4X/season)																																																
Bug vacuuming for lygus (2X/wk)																																																
Fungicide applications (1X/2wk)																																																
Herbicide applications - preplant																																																
Hand weeding (season long maint)																																																
Hand weeding - organic																																																
Vertebrate pest management ^t																																																



Pest Management Activities	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Scouting																																																
Soil Fumigation (see above Land Prep.)																																																
Insecticide applications (1X/2-4wk)																																																
Predatory mites release (1-4X/season)																																																
Bug vacuuming for lygus (2X/wk)																																																
Fungicide applications (1X/2wk)																																																
Herbicide applications - preplant																																																
Hand weeding (season long maint)																																																
Hand weeding - organic																																																
Vertebrate pest management ^t																																																

Key to abbreviations

P = Planting in nurseries

H = Harvest/digging plants in nurseries

B = beginning of season; E = end of season

Footers

z = ground preparation includes ripping, plowing, disking, leveling and other operations to prepare soil for listing.

y = flat fumigation occurs prior to listing; generally not practiced for summer planting.

x = bedding up includes bed formation, drip irrigation tape installation, preplant fertilizer application and plastic mulch laying.

w = bed fumigation occurs after bedding up.

v = Frost protection not practiced in Watsonville or Salinas.

u = bloom removal not practiced in Oxnard due to need for early fruit.

t = vertebrate pest management includes rodents (mice, voles, gophers, ground squirrels), rabbits, deer and birds.

s = early harvest is used for earliest planting in Baja California and Oxnard

Fungicide applications include Ridomil for Phytophthora

APPENDIX 2a. Description of Cultural Practices, 2016*

Cultural Practices	Description of Related Activities	Hr/Day/ Person	Size of Crew	People/ Acre	Acres/ Day/ Person
Bed preparation	List (shape) beds and prepare soil for transplanting and placement of plastic mulch on top of soil	5	2	0.7	30
Bed preparation	Pre-plant fertilizer application	5	6	1	6
Bed preparation	Install drip tape by tractor by laying tape and then burying in plant rows	5	6	1	6
Transplanting	Performed by hand	8	35	7	0.15
Irrigation	Sprinkler or drip, dependent upon operation and time of season	4	2	0.1	15
Fertilizer application	Routinely done through drip irrigation system after plants are established	4	2	0.1	15
Harvest	season	8	35	27	0.22
*assumes 64-inch bed with 24,000 plants per acre					

APPENDIX 2b. Description of Pest Management Activities, 2016

Pest Management Activities	Description of Related Activities	Hrs/Day/ Person	Size of Crew	People/ Acre	Acres/ Day/ Person
Soil Sampling	Taken by hand with soil probe or shovel, for analysis of composition, nutrients, and insect pests	1	1	<1	100 +
Water Analysis	Taken by hand to determine water quality (NPK, salinity, nitrates, micros, etc.)	1	1	<1	
Scouting	Row-by-row observation of plant health to examine growth, berry development, pest problems, etc; requires expertise in pests, diseases, and quality	2	1	<1	150
Mulching and Soil Fumigation*	Warms beds and prevents weeds; 4 drivers and 8 riders lay plastic mulch over planting beds and shovel dirt over edges; fumigation controls weeds, insects, nematodes, and diseases, and promotes vigorous growth	-	13	<1	1.5
Insecticide Applications	Mechanically applied, usually with sprayer attached to tractor	1	5	<1	6
Fungicide Applications	Mechanically applied, usually with sprayer attached to tractor	1	5	<1	6
Herbicide Applications	Mechanically applied, usually with sprayer attached to tractor	1	5	<1	6
Vertebrate Control	techniques.	1	1	<1	NA
Hand Weeding	Row-by-row pulling to remove weeds	8	6	<1	6
*assumes flat fumigation					

a. Orange County/San Diego Production Region

[illegible]

b. Oxnard Production Region

[illegible]

APPENDIX 3. Seasonal Pest Occurrence in California Strawberries

c. Santa Maria Production Region

[illegible]

d. Watsonville Production Region

[illegible]

APPENDIX 4. Efficacy of Insect Management Tools Used in California Strawberries

a. Primary Insects

REGISTERED CHEMICAL PRODUCT	Trade Name	Two-spotted Spider Mites	Lygus Bugs	Cyclamen Mites	Aphids	Root Weevils	Western Flower Thrips	Cutworms	Beet Armyworms	Whiteflies
Abamectin	Agri-mek®	++++	+	+++	+	+	++	+	+	++
Azadirachtin	Neemix®	+	+ - + +	+	++ to ++++	+	++	+	+	+
Bacillus thuringiensis	Bt-various	+	+	+	+	+	+	++	++	+
Bifenthrin	Brigade®	++++	++ to ++++	++ to +++	++	++ to +++	++	++	++	++
Bifenxate	Acramite®	++++	+	+	+	+	+	+	+	+
Buprofezin	Applaud®	+	+	+	+	+	+	++	++	++ to +++
Carbaryl	Sevin®	+	++	+	++	++	+	+++	+++	+
Chloropicrin	Chloropicrin	++	+	+	+	++++	+	++	+	+
Chlorpyrifos	Lorsban®	+	+	+	++ to +++	+++	+	+++	++	+
Diazinon	various	+	++	+	+++	++	++	+++	++ to +++	+
Endosulfan	Thiodan®	++	+++	++++	+++	++	++	++	++	++ to +++
Etoxyzole	Baroque®	++++	+	+	+	+	+	+	+	
Fenbutatin-oxide	Vendex®	+ - + +	+	+ - + +	+	+	+	+	+	+
Fenpropathrin	Danitol®	++ to +++	++ to ++++	++ to +++	++	++ to +++	++ to ++++	++	++	++
Hexythiazox	Savey®	+++*	+	+	+	+	+	+	+	+
Imidacloprid	Admire®	+	++	+	++ to +++	+	+	+	+++ to ++++	
Malathion	various	+	++ to +++	+	+++	+	++	++	+	++
Metaldehyde	Deadline®	+	+	+	+	+	+	+	+	+
Metam Sodium	Metam Sodium	+	+	+	+	+	+	+	+	+
Methomyl	Lannate®	+	++++**	+	++ to ++++		++ to ++++	+++ to ++++	+++ to ++++	+++
Methoxyfenozide	Intrepid®	+	----	----	----	----	----	----	----	----
Methyl Bromide	Methyl Bromide	++	+	+	+	++++	+	+	+	+
Naled	Dibrom®	+	++	+	+++	+	++	++	++	+
Potash Soap	M-Pede®	++	+	+	++	+	+	+	+	+
Pyrethrin	various	+	+	+	+	+	+	+	++	+
Pyriproxifen	Esteem®	+	+	+	+++ to ++++	----	----	----	----	----
Spinosad	Success®	+	+	+	+	+	++++ to +++	++	+++	+
Thiamethoxam	Actara®	+	++	+	++ to +++	+	+	+	+++	----
UN-REGISTERED CHEMICAL PRODUCT	Trade Name	Two-spotted Spider Mites	Lygus Bugs	Cyclamen Mites	Aphids	Root Weevils	Western Flower Thrips	Cutworms	Beet Armyworms	Whiteflies
Lambda cyhalothrin	Warrior®	----	++ to +++	+++ to ++++	+++ to ++++	----	----	----	----	----
Milbemectin	Mesa®	++++	+	++ to +++	+	+	++	+	+	+
Pyridaben	Pyramite®	++ to +++	+	+	+	+	+	+	+	+

Control Rating: ++++ = excellent; +++ = good and reliable; ++ = moderate and variable; + = poor; +/- = minimal and often ineffective; ---- = ineffective.

APPENDIX 4 (cont'd). Efficacy of Insect Management Tools Used in California Strawberries

a. Primary Insects

[illegible]

APPENDIX 4. Efficacy of Insect Management Tools Used in California Strawberries

b. Secondary Insects

REGISTERED CHEMICAL PRODUCT	Trade Name	Cabbage Looper	Corn Earworm	European Earwig	Hoplia Beetle	White Grub	Garden Tortrix	Saltmarsh Caterpillar	Vinegar Fly
Abamectin	Agri-mek®	+	++++	+	+	+	+	+	+
Azadirachtin	Neemix®	++	++	+	+	+	+	+	+
<i>Bacillus thuringiensis</i>	Bt	++++	++	+	+	+	++	++	+
Bifenthrin	Brigade®	+++	++	+	+	+	++	++	+++ to ++++
Bifentate	Acramite®	+	+	+	+	+	+	+	+
Buprofezin	Applaud®	----	++	----	----	----	----	----	----
Carbaryl	Sevin®	++	++	++	+	+	+	+	+
Chloropicrin	Chloropicrin	+	+	+	++++	++++	+	+	+
Chlorpyrifos	Lorsban®	+++	+++	+++	+++	+++	+++	+++	++
Diazinon	Diazinon	+++	++	+++	++	++	+++	++	+
1,3-Dichloropropene	Telone®	+	+	+	----	----	+	+	+
Etoxazole	Zeal	+	+	+	+	+	+	+	+
Fenbutatin-oxide	Vendex®	+	+	+	+	+	+	+	+
Fenpropathrin	Danitol®	+++	++	+	+	+	++	++	++ to +++
Hexythiazox	Savey®	+	+	+	+	+	+	+	+
Imidacloprid	Admire®	+	+	+		++	+	+	+
Malathion	Malathion	++	++	++	+	+	+++	+++	+
Metaldehyde	Deadline®	+	+	+	+	+	+	+	+
Metam Sodium	Vapam®	+	+	+	++	++	+	+	+
Methomyl	Lannate®	+++ to ++++	++++	+++	++	++++	++++	++	+++
Methyl Bromide	Methyl Bromide	+	+	+	++++	++++	+	+	+
Naled	Dibrom®	++	++	+	+	+	++	+	++
Potash Soap	M-Pede®	+	+	+	+	+	+	+	+
Pyrethrin	various	++	+	+	+	+	+	+	++
Spinosad	Success®	+++	+++	+	+	+	+++	+++	+
UN-REGISTERED CHEMICAL PRODUCT	Trade Name	Cabbage Looper	Corn Earworm	European Earwig	Hoplia Beetle	White Grub	Garden Tortrix	Saltmarsh Caterpillar	Vinegar Fly
Lambda cyhalothrin	Warrior®	++++	+++	----	----	----	----	----	+++
Pyridaben	Pyramite®	+	+	+	+	+	+	+	+

Control Rating: ++++ = excellent; +++ = good and reliable; ++ = moderate and variable; + = poor; +/- = minimal and often ineffective; ---- = ineffective.

APPENDIX 4 (cont'd). Efficacy of Insect Management Tools Used in California Strawberries

b. Secondary Insects

NON-CHEMICAL MANAGEMENT TOOL	Trade Name	Cabbage Looper	Corn Earworm	European Earwig	Hoplia Beetle	White Grub	Garden Tortrix	Saltmarsh Caterpillar	Vinegar Fly
Field Placement		+	+	+	++ to ++++	++++	+	+	+
Field Monitoring		++	+++	++	++	++	+	+	+++
Use of Economic Thresholds		+	++	+	+	+	+	+	+
Use of Modles		+	+++	+	+	+	+	+	++
Sanitation		+	+	++ to +++	++	+	+	+	++++
Biological Control		+++	++	+	+	+	+	+	+
Weed-Host Control		+	+	+	++	++	+	+	+
Flooding		+	+	+	+	+	+	+	+
Barriers		+	+	+	+	+	+	++	+++
Ripe Fruit Removal		+	+	+	+	+	+	+	++++
Crop Rotation		+	+	+	+++	+++	+	+	+
Dust Reduction		+	+	+	+	+	+	+	+
Soil Solarization		+	+	+	++	++	+	+	+
Plastic Covers		++	++	+	+	+	++	++	+
Sticky Barriers		+	+	+	+	+	+	+	+
Vacuuming		+	+	+	+	+	+	+	+
Topping		+	+	+	+	+	+	+	+
Certified Transplants		+ to ++++	+	+	+	+	+	+	+
Resistant Varieties		+	+	+	+	+	+	+	+
Resistant Varieties		+	+	+	+	+	+	+	+

Control Rating: ++++ = excellent; +++ = good and reliable; ++ = moderate and variable; + = poor; +/- = minimal and often ineffective; ---- = ineffective.

APPENDIX 5. Relative Toxicity of Insect Management Tools to Beneficial Organisms in California Strawberries

Common Name	Trade Names	Mode of action ¹	Selectivity ² (affected groups)	Predatory mites ³	General predators ⁴	Parasites ⁴	Honey bees ⁵	Duration of impact to natural enemies ⁶
abamectin	Agri-Mek	6	moderate (mites, leafminers)	M	L	M/H	I	long to predatory mites and affected insects
acequinocyl	Kanemite	20B	narrow (mites)	— ⁷	—	—	III	—
acetamiprid	Assail	4A	moderate (sucking insects, larvae)	— ⁸	— ⁷	—	II	moderate
azadirachtin	Neemix	un	broad (insects, mites)	M	L/M	L/M	II	short
<i>Bacillus thuringiensis</i> s	Agree, Xentari	11A	narrow (caterpillars)	L	L	L	II	short
<i>Bacillus thuringiensis</i> s	Dipel	11A	narrow (caterpillars)	L	L	L	III	short
Beauveria bassiana	BotaniGard	—	broad (insects)	—	—	—	II	—
bifenazate	Acramite	20D	narrow (spider mites)	L	L	L	II	short
bifenthrin	Brigade	3A	broad (insects, mites)	H	H	H	I	long
<i>Burkholderia rinojensis</i>	Venerate	—	broad (insects, mites)	—	—	—	—	—
carbaryl bait	Sevin	1A	narrow (cutworms, army- worms, grasshoppers, etc.)	L	L	L	I	short
chlorantraniliprole	Coragen	28	narrow (primarily caterpillars)	L	L	L/M	III	short
<i>Chromobacterium subts</i>	Grandevo	—	broad (insects, mites)	—	—	—	—	—
diazinon		1B	broad (insects, mites)	L	H	H	I	moderate to long
etoxazole	Zeal	10B	narrow (mites)	H ⁷	L	—	II	short
fenbutatin oxide	Vendex	12B	narrow (pest mites)	L	L	L	III	short
fenpropathrin	Danitol	3A	broad (insects, mites)	H	H	H	I	—
Fenpyroximate	FujiMite 5SC	21A	narrow (mites, some insects)	H	L	L	III	short
hexythiazox	Savey	10A	narrow (mites)	M	L	L	II	short to moderate
imidacloprid	Admire	4A	narrow (sucking insects, beet armyworm, cutworms)	—	L	—	I	—
insecticidal soap	M-Pede	—	broad (exposed insects, mites)	L	L	L	III	short
<i>Isaria fumosorosea</i>	Pfr-97	—	broad (insects, mites)	—	—	—	—	short
malathion		1B	broad (insects, mites)	M	H	H	I	moderate
<i>Metarhizium brunneum</i>	Met52		broad (insects, mites)	—	—	—	—	—
methomyl	Lannate	1A	broad (insects, mites)	H	H	H	I	moderate
methoxyfenozide	Intrepid	18	narrow (caterpillars)	L	L	L	II	short
naled	Dibrom	1B	broad (insects, mites)	H	H	H	I	—
neem oil	Trilogy	—	broad (soft-bodied insects, mites)	L	L	L	II	short
novaluron	Rimon	15	narrow (insects)	L	L/M	—	—	short to moderate
paraffinic oil	JMS Stylet Oil	—	broad (exposed insects, mites)	L	L	L	II	short
petroleum oil	petroleum oil	—	broad (exposed insects, mites)	L ⁹	L	L	II	short
pyrethrin	PyGanic	3A	broad (insects)	—	M	M	I	short
pyrethrin + piperonyl bu	Pyrenone	3A/—	broad (insects)	—	—	—	I	short to moderate
pyriproxyfen	Esteem	7C	narrow (whiteflies, etc.)	L	H ¹⁰	L	II	long
rosemary oil	Hexacide	—	broad (exposed insects, mites)	L	L	L	III	—
spinetoram	Radiant	5	narrow (caterpillars, thrips, whiteflies, fruit flies, leafmine	M	M ¹¹	L/M	II	moderate ¹²
spinosad	Entrust, Succes	5	narrow (caterpillars, thrips, whiteflies, fruit flies, leafmine	M	M ¹⁷	L/M	II	short to moderate ¹¹
spiromesifen	Oberon SC	23	narrow (mites, whiteflies)	—	—	—	II	—
thiamethoxam	Actara	4A	narrow (sucking insects)	— ⁸	—	M	I	moderate

H = high M = moderate L = low — = no information

- 1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than
- 2 Selectivity: Broad means it affects most groups of insects and mites; narrow means it affects only a few specific groups.
- 3 Toxicities are generally to *Phytoseiulus persimilis*.
- 4 Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific insecticide depends on factors
- 5 Ratings are as follows: I-Do not apply or allow to drift to plants that are flowering; II-Do not apply or allow to drift to plants that are flowering, except
- 6 Duration: Short means hours to days; moderate means days to two weeks; and long means many weeks or months.
- 7 Acute toxicity low but reproductive capacity is reduced.
- 8 May cause an increase in spider mites.
- 9 Use lowest rates for best management of predatory mite to spider mite ratio.
- 10 Kills lady beetles.
- 11 Toxic to some natural enemies (lacewing and syrphid fly larvae, predatory beetles and thrips) when sprayed and up to 5 to 7 days after, especially
- 12 Residual is moderate if solution is between pH of 7 to 8.

APPENDIX 6. Efficacy of Weed Management Tools Used in California Strawberries

	Common Name (Trade Name)	Mode of Action1	ANNUAL WEEDS																				PERENNIAL WEEDS					
			barley, hare	barnyardgrass	bluegrass, annual	burclovers	chickweed, common	filarees	fleabane, hairy	goosefoot, nettleleaf	groundsel, common	horseweed	lambsquarters, common	mallow, little (cheeseweed)	nettle, burning	pigweeds	pineapple-weed	puncturevine	purslane, common	ryegrass, Italian	sowthistles	sweetclovers	volunteer grains	bermudagrass (regrowth)	bermudagrass (seedling)	bindweed, field (regrowth)	bindweed, field (seedling)	nutsedge, yellow
FUMIGANTS	1,3-dichloropropene / chloropicrin (InLine, Telone)	NA	C	C	C	N	C	N	—	C	C	—	C	P	C	C	C	P	C	C	C	N	C	T	C	N	N	P
	chloropicrin (Tri-Clor)	NA	C	C	C	N	C	N	—	C	C	—	C	P	C	C	C	P	C	C	C	N	C	T	C	N	N	P
	methyl bromide*	NA	C	C	C	N	C	N	C	C	C	—	C	N	C	C	C	P	C	C	C	N	C	P	C	P	—	C
	metam potassium (K-Pam HL)	NA	C	C	C	N	C	P	—	C	C	—	C	P	C	C	C	P	C	C	C	P	C	T	C	T	N	P
	metam sodium* (Vapam HL)	NA	C	C	C	N	C	P	C	C	C	C	C	P	C	C	C	P	C	C	C	P	C	P	C	T	N	P
PRE-EMERGENCE	DCPA (Dacthal)	3	C	C	C	N	C	P	N	C	C	N	C	P	C	C	P	P	C	C	C	N	P	N	C	N	N	N
	flumioxazin (Chateau)	14	C	—	—	C	C	C	C	C	C	C	C	C	C	C	—	—	—	—	C	C	C	—	—	—	—	N
	napropamide (Devrinol)	15	C	C	C	P	C	C	N	P	C	N	C	P	P	C	P	P	C	C	C	P	C	N	C	N	N	N
	oxyfluorfen (Goal)	14	P	P	P	N	N	C	P	C	C	P	C	C	C	C	P	C	C	N	C	P	P	N	N	N	N	N
	pendimethalin (Prowl H2O)	3	C	C	C	—	C	N	N	C	N	N	C	P	N	C	N	P	C	C	N	—	—	C	N	P	N	N
POST-EMERGENCE	carfentrazone (Shark EW)	14	N	N	N	—	P	—	N	—	—	N	—	C	C	C	—	—	N	N	N	N	—	N	N	C	P	N
	clethodim (Select Max)	1	C	C	C	N	N	N	N	N	N	N	N	N	N	N	N	N	C	N	N	C	C	C	C	N	N	N
	paraquat* (Gramoxone)	22	P	P	P	P	C	P	P	C	C	P	C	N	P	C	P	C	C	P	P	P	P	T	P	T	C	T
	pelargonic acid (Scythe)	27	—	C	C	—	C	P	P	—	C	—	P	C	—	P	—	—	C	—	—	—	—	N	—	N	—	N
	sethoxydim (Poast)	1	C	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	C	N	N	C	P	C	C	N	N	N
CULTURAL CONTROL	Solarization	NA	C	C	C	C	C	C	—	—	C	—	C	C	C	C	C	P	P	C	C	N	C	P	C	T	C	T

T	top kill only
C	control
P	partial control
N	no control
—	no information

*Permit required from county agricultural commissioner for purchase or use.

NA-Not applicable

1-Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode of action numbers are useful in planning mixtures or rotations of herbicides with different modes of action.

2-For use in nurseries under the quarantine and pre-shipment (QPS) exemption.

3-For fallow bed use prior to transplanting strawberries.

APPENDIX 7. Efficacy of Disease Management Tools Used in California Strawberries

[illegible]

APPENDIX 7 (cont'd). Efficacy of Disease Management Tools Used in California Strawberries

Fungicide	Resistance risk (FRAC) ¹	Powdery mildew	Gray mold	Anthraco nose	Angular leaf spot	Common leaf spot	Mucor rot	Rhizopus rot	Leather rot	Crown rot	Red stele
Biologicals/ Natural Products											
Fracture	low	++	+	----	----	----	----	----	----	----	----
Serenade ASO, Serenade Opti	low	++	+	----	----	----	----	----	----	----	----
Actinovate ⁷	low	+	----	+	----	----	----	----	----	----	----
Cinnacure	low	+	----	----	----	----	----	----	----	----	----
Double	low	+	----	----	----	----	----	----	----	----	----
M-Pede	low	+	----	----	----	----	----	----	----	----	----

Rating: ++++ = excellent and consistent; +++ = good and reliable; ++ = moderate and variable; + = limited and/or erratic; +/- = minimal and often ineffective; ---- = ineffective; NR = not registered; and ND = no data.

**

Not registered, label withdrawn or inactive in California.

- Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
- To reduce the risk of resistance development, start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications.
- Foliar applications provide systemic treatment.
- Ridomil Gold SL is the only formulation registered. If the GR formulation is applied to a previous crop that must be removed, it has a 0-day plantback interval.
- More than 4 applications causes severe stunting.
- Nonpersistent resistant populations of *Botrytis cinerea* to fenhexamid occur with repeated use of FRAC group 17 fungicides.
- Plant dip (nurseries) or foliar spray (field use).
- Not for use in nurseries, on nursery transplants, or greenhouses (check label for details).
- Bravo is registered under a 24c special local needs for nursery use only on non-bearing plants. It is used as a dip treatment of transplants.
- Velum One is a fluopyram formulation for chemigation. Soil applications are designed for nematode management but may also suppress powdery mildew.

APPENDIX 8. Efficacy of Vertebrate Pest Management Tools Used in California Strawberries

PEST MANAGEMENT TOOL	Birds	Ground Squirrels	Meadow Mice	Moles	Mule Deer
Chemical					
Aluminum Phosphide		E			
Zinc Phosphide		E			
Non-Chemical					
Visual Frightening Devices	F	F			P
Noisemakers	F	F			F
Traps	F	F			F
Plastic Netting	E				
Habitat Elimination	G	G	G	G	E
Barriers	G				F
E = excellent; G = good; F = fair; P = poor					

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
(E,E)-9, 11-TETRADECADIEN-1-YL ACETATE	Pheromone				1	0		0	241	45		143	1%	0%	0%	0%
(S)-CYPERMETHRIN	Insecticide		Conventional		1			1	10			10	0%	0%	0%	0%
1,3-DICHLOROPROPENE	Fumigant	Inline, Telone	Conventional		2,168,991	1,630,555	1,535,073	1,778,207	16,024	14,850	15,555	15,476	39%	37%	41%	39%
4-NONYLPHENOL, FORMALDEHYDE RESIN, PROPOXYLATED	Insecticide		Conventional		5,168	4,201	5,342	4,903	37,197	33,867	35,294	35,452	90%	84%	93%	89%
ABAMECTIN	Acaricide	Abamectin, Abamex, Abba, Agmectin, agri-mek, Avow, Borrada, Clinch	Conventional	Two-spotted mites, cyclamen mites	978	570	530	692	58,141	37,738	30,576	42,152	140%	93%	81%	105%
ACEQUINOCYL	Acaricide	Kanemite	Conventional	Two-spotted mites	7,970	9,480	6,599	8,016	20,856	24,382	16,833	20,690	50%	60%	44%	52%
ACETAMIPRID	Insecticide	Assail	Conventional	Lygus, aphids	4,454	5,687	4,253	4,798	35,765	45,591	33,688	38,348	86%	113%	89%	96%
ACETIC ACID	Herbicide		Organic		0	1	1	1	138	55	110	101	0%	0%	0%	0%
ACIBENZOLAR-S-METHYL	Fungicide		Conventional				16	16			664	664	0%	0%	2%	1%
ALKYL (50%C14, 40%C12, 10%C16) DIMETHYLBENZYL AMMONIUM CHLORIDE	Algaecide, Microbiocide		Conventional		0			0	38			38	0%	0%	0%	0%
ALPHA-PINENE BETA-PINENE COPOLYMER	Pheromone				19,659	18,387	18,541	18,862	82,212	72,238	60,964	71,805	198%	178%	161%	179%
ALUMINUM PHOSPHIDE	Fumigant		Conventional		0	0	0	0	2	2	6	3	0%	0%	0%	0%
AMMONIUM NITRATE	Fertilizer		Conventional		204	374	118	232	251	436	267	318	1%	1%	1%	1%
AMMONIUM NONANOATE	Herbicide					69	100	85		21	10	16	0%	0%	0%	0%
AMMONIUM PROPIONATE	Microbiocide				10,549	15,402	19,122	15,024	28,230	32,410	40,110	33,583	68%	80%	106%	85%
AUREOBASIDIUM PULLULANS STRAIN DSM 14940	Fungicide					7	144	76		30	629	329	0%	0%	2%	1%
AUREOBASIDIUM PULLULANS STRAIN DSM 14941	Fungicide					7	144	76		30	629	329	0%	0%	2%	1%
AZADIRACHTIN	Insecticide, Nematicide	Neemix, Margosan, Aza-Direct, AzaGuard, Azatin, Azatrol,	Organic		942	1,092	918	984	33,252	37,997	30,031	33,760	80%	94%	79%	84%
AZOXYSTROBIN	Fungicide	Abound, Quadris FlowableEquation SC, Satori, TREVO; azoxystrobin/ difenoconazole: Quadris Top; and azoxystrobin/ propiconazole: Quilt Xcel	Conventional		4,161	5,111	4,179	4,484	20,657	24,460	19,118	21,412	50%	60%	50%	54%
BACILLUS AMYLOLIQUEFACIENS STRAIN D747	Fungicide	Double Nickel LC	Organic		9,959	23,079	34,623	22,553	8,500	6,661	7,200	7,454	20%	16%	19%	19%
BACILLUS PUMILUS, STRAIN QST 2808	Fungicide	Sonata	Organic		421	596	248	422	5,393	6,408	2,785	4,862	13%	16%	7%	12%
BACILLUS SUBTILIS GB03	Fungicide		Organic		0	0	0	0	241	341	550	377	1%	1%	1%	1%
BACILLUS SUBTILIS MBI600	Fungicide		Organic				7	7			91	91	0%	0%	0%	0%

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
BACILLUS THURINGIENSIS (BERLINER)	Insecticide	Dipel, Javelin, Biobit, Condor, CoStar, Crymax, Deliver	Organic		0			0	9			9	0%	0%	0%	0%
BACILLUS THURINGIENSIS (BERLINER), SUBSP. AIZAWAI, GC-91 PROTEIN	Insecticide		Organic		2,969	1,689	1,832	2,163	7,073	4,436	4,146	5,218	17%	11%	11%	13%
BACILLUS THURINGIENSIS (BERLINER), SUBSP. AIZAWAI, SEROTYPE H-7	Insecticide		Organic		250	54	0	102	2,437	492	42	990	6%	1%	0%	2%
BACILLUS THURINGIENSIS (BERLINER), SUBSP. ISRAELENIS, SEROTYPE H-14	Insecticide		Organic					#DIV/0!					0%	0%	0%	0%
BACILLUS THURINGIENSIS (BERLINER), SUBSP. KURSTAKI STRAIN SA-12	Insecticide		Organic		3	70		36	184	123		153	0%	0%	0%	0%
BACILLUS THURINGIENSIS (BERLINER), SUBSP. KURSTAKI, SEROTYPE 3A,3B	Insecticide		Organic		7	11	0	6	64	86	4	51	0%	0%	0%	0%
BACILLUS THURINGIENSIS (BERLINER), SUBSP. KURSTAKI, STRAIN SA-11	Insecticide		Organic		16,387	19,010	15,647	17,015	19,408	22,252	17,668	19,776	47%	55%	47%	49%
BACILLUS THURINGIENSIS, SUBSP. AIZAWAI, STRAIN ABTS-1857	Insecticide		Organic		15,861	19,625	25,934	20,473	26,761	27,470	34,062	29,431	64%	68%	90%	74%
BACILLUS THURINGIENSIS, SUBSP. AIZAWAI, STRAIN SD-1372, LEPIDOPTERAN ACTIVE TOXIN(S)	Insecticide		Organic			32		32		213		213	0%	1%	0%	0%
BACILLUS THURINGIENSIS, SUBSP. KURSTAKI, STRAIN ABTS-351, FERMENTATION SOLIDS AND SOLUBLES	Insecticide		Organic		12,513	15,571	14,235	14,106	16,055	22,351	17,999	18,801	39%	55%	47%	47%
BACILLUS THURINGIENSIS, SUBSP. KURSTAKI, STRAIN HD-1	Insecticide	XenTari	Organic		27	1	3	10	130	13	34	59	0%	0%	0%	0%
BEAUVERIA BASSIANA STRAIN GH	Insecticide	BotaniGard, Mycotrol	Conventional		59	151	74	95	252	522	167	314	1%	1%	0%	1%
BENSULIDE	Herbicide						24	24			34	34	0%	0%	0%	0%
BENZOIC ACID	Fungicide				0	0	1	0	281	340	209	276	1%	1%	1%	1%
BETA-CONGLUTIN	Fungicide					3,493	3,653	3,573		6,589	7,032	6,810	0%	16%	19%	12%
BETA-PINENE POLYMER	Insecticide				2			2	6			6	0%	0%	0%	0%
BIFENAZATE	Insecticide, Acaricide	Acramite, Banter	Conventional		24,523	19,641	15,896	20,020	50,242	39,317	32,324	40,628	121%	97%	85%	101%
BIFENTHRIN	Insecticide	Brigade, Athena, Bifenture, Brigadier, Fanfare	Conventional	Lygus	6,750	6,982	5,323	6,352	63,978	66,493	51,166	60,546	154%	164%	135%	151%
BORAX	Fungicide	Prev-AM Ultra	Conventional		312	289	212	271	22,621	19,030	12,312	17,987	55%	47%	32%	45%
BOSCALID	Fungicide	boscalid/ pyraclostrobin: Pristine	Conventional		27,576	23,245	16,954	22,592	79,548	63,619	48,243	63,803	192%	157%	127%	159%

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
BRODIFACOU	Rodenticide				-	-	-	-	65		65		0%	0%	0%	0%
BUPROFEZIN	Insecticide	Courier		whiteflies	1,254	1,207	401	954	3,734	3,577	1,177	2,830	9%	9%	3%	7%
BURKHOLDERIA SP STRAIN A396 CELLS AND FERMENTATION MEDIA	Fungicide					42,874	13,800	28,337		4,175	1,438	2,807	0%	10%	4%	5%
BUTYL ALCOHOL					21		7	14	138		67	102	0%	0%	0%	0%
CALCIUM CHLORIDE	Fertilizer					2	8	5		13	113	63	0%	0%	0%	0%
CAPTAN	Fungicide	Captan, Captec	Conventional		338,828	449,505	515,065	434,466	196,408	185,031	200,810	194,083	473%	457%	530%	487%
CAPTAN, OTHER RELATED	Fungicide	captan/ fenhexamid: CaptEcate	Conventional		4,234	3,399	3,492	3,708	107,135	80,546	83,755	90,479	258%	199%	221%	226%
CARBARYL	Insecticide	Carbaryl, Sevin	Conventional	thrips, cutworms	1,031	1,540	1,001	1,191	599	785	812	732	1%	2%	2%	2%
CARFENTHAZONE-ETHYL	Herbicide	Shark	Conventional		31	27	30	29	1,692	1,333	1,191	1,405	4%	3%	3%	4%
CHLORANTRANILIPROLE	Insecticide	Coragen, Voliam Flexi	Conventional		2,272	1,961	2,118	2,117	38,921	33,519	35,887	36,109	94%	83%	95%	90%
CHLOROPHACINONE	Rodenticide				-	0		0	5	232		119	0%	1%	0%	0%
CHLOROPICRIN	Fumigant	Tri-clor, Pic-Clor 60	Conventional		6,589,227	6,203,336	6,592,941	6,461,835	33,856	32,270	32,871	32,999	82%	80%	87%	83%
CHLOROTHALONIL	Fungicide	Bravo, Echo, Equus DF	Conventional		3,286	1,809	3,182	2,759	2,937	1,718	2,860	2,505	7%	4%	8%	6%
CHLORPYRIFOS	Insecticide	Chlorpyrifos, Lorsban, CPF, Eraser, Govern, Hatchet	Conventional	Lygus, corn earworms, cutworms, thrips, aphids	4,993	2,153	1,392	2,846	5,318	2,299	1,458	3,025	13%	6%	4%	7%
CHLORTHAL-DIMETHYL	Herbicide	Dacthal	Conventional			5		5		1		1	0%	0%	0%	0%
CHROMOBACTERIUM SUBTUGAE STRAIN PRAA4-2	Insecticide	Grandevo	Organic		18,368	14,116	5,600	12,695	22,374	18,463	7,484	16,107	54%	46%	20%	40%
CITRIC ACID	Herbicide				5,601	7,899	9,791	7,764	32,278	36,485	45,995	38,253	78%	90%	121%	96%
CLARIFIED HYDROPHOBIC EXTRACT OF NEEM OIL	Insecticide	Trilogy	Organic		80,332	100,940	55,361	78,878	27,543	31,863	17,316	25,574	66%	79%	46%	64%
CLETHODIM	Herbicide	Arrow 2, Cleanse 2, Cleo 26.4, Dakota, Envoy,	Conventional		7		0	4	121		0	61	0%	0%	0%	0%
COPPER HYDROXIDE	Fungicide				6,699	4,309	4,434	5,147	3,044	2,184	2,025	2,418	7%	5%	5%	6%
COPPER OCTANOATE	Fungicide				3,906	2,161	2,308	2,792	4,066	3,543	2,710	3,440	10%	9%	7%	9%
COPPER OXIDE (OUS)	Fungicide					22	328	175		11	268	140	0%	0%	1%	0%
COPPER OXYCHLORIDE	Fungicide					2		2		4		4	0%	0%	0%	0%
COPPER SULFATE (BASIC)	Fungicide				1,871	6,729	1,058	3,219	964	639	561	721	2%	2%	1%	2%
COPPER SULFATE (PENTAHYDRATE)	Fungicide						20	20			157	157	0%	0%	0%	0%
COTTONSEED OIL	Insecticide					23		23		52		52	0%	0%	0%	0%
CYFLUFENAMID	Fungicide	Torino	Conventional		768	752	550	690	33,543	32,698	23,927	30,056	81%	81%	63%	75%
CYFLUMETOFEN	Acaricide	Nealta, Sultan	Conventional	Two-spotted mites		2,330	5,359	3,844		12,871	29,536	21,203	0%	32%	78%	37%
CYPRODINIL	Fungicide	cyprodinil/fludioxonil: Switch	Conventional		25,788	24,028	25,251	25,022	81,044	73,761	78,611	77,805	195%	182%	207%	195%
DIAZINON	Insecticide	Diazinon	Conventional	Lygus, corn earworms, cutworms, aphids	201	170	152	175	206	181	148	178	0%	0%	0%	0%
DIFENOCONAZOLE	Fungicide				601	1,211	384	732	5,707	10,645	3,466	6,606	14%	26%	9%	16%
DIMETHYL ALKYL TERTIARY AMINES	Algaecide, Microbiocide				0	0	1	0	281	340	209	276	1%	1%	1%	1%

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
DIMETHYL DICOCOALKYL AMMONIUM SALT WITH NAPHTHALENESULFONIC ACID, FORMALDEHYDE CONDENSATE	Microbiocide				1	26		13	11	135		73	0%	0%	0%	0%
DIPHACINONE	Rodenticide				0	0	0	0	754	1,057	274	695	2%	3%	1%	2%
E-11-TETRADECEN-1-YL ACETATE	Pheromone				19	4		12	241	45		143	1%	0%	0%	0%
EMULSIFIABLE METHYLATED VEGETABLE OIL	Insecticide				1,390	1,442	1,878	1,570	5,071	5,408	6,289	5,589	12%	13%	17%	14%
ENDOSULFAN	Insecticide	Thiodan, Thionex	Conventional		1	841	576	473	5	841	644	497	0%	2%	2%	1%
ETOXAZOLE	Insecticide	Zeal	Conventional	Two-spotted mites	936	559	382	626	7,201	4,192	2,812	4,735	17%	10%	7%	12%
FENBUTATIN-OXIDE	Acaricide	Vendex	Conventional	Two-spotted mites	6,623	1,866	489	2,993	4,631	1,333	293	2,086	11%	3%	1%	5%
FENHEXAMID	Fungicide	Elevate	Conventional		38,120	31,887	34,367	34,791	56,496	47,386	50,162	51,348	136%	117%	132%	128%
FENPROPATHRIN	Insecticide	Danitol	Conventional	Lygus	6,840	8,300	5,809	6,983	23,295	29,493	20,391	24,393	56%	73%	54%	61%
FENPYRAZAMINE	Fungicide					1		1		2		2	0%	0%	0%	0%
FENPYROXIMATE	Acaricide	FujiMite	Conventional	Two-spotted mites, cyclamen	709	320	408	479	7,310	3,347	4,529	5,062	18%	8%	12%	13%
FERRIC SODIUM EDTA	Herbicide				69	7		38	272	18		145	1%	0%	0%	0%
FERROUS SULFATE	Herbicide				68	107		88	1,927	3,215		2,571	5%	8%	0%	4%
FLONICAMID	Insecticide	Beleaf	Conventional		4,393	6,030	4,869	5,097	50,812	69,203	56,178	58,731	122%	171%	148%	147%
FLUBENDIAMIDE	Insecticide	Belt, Vetica	Conventional		263	502	278	348	4,512	7,663	3,922	5,366	11%	19%	10%	13%
FLUDIOXONIL	Fungicide				17,192	16,019	16,834	16,682	81,044	73,761	78,611	77,805	195%	182%	207%	195%
FLUMIOXAZIN	Herbicide	Chateau, Tuscany, Warfox	conventional		740	694	652	696	10,688	10,002	8,091	9,594	26%	25%	21%	24%
FLUOPYRAM	Fungicide	One component of Luna Sensation				-	1,680	840		0	12,481	6,240	0%	0%	33%	11%
FLUPYRADIFURONE	Insecticide	Sivanto				1,554	3,072	2,313		8,688	17,090	12,889	0%	21%	45%	22%
FLUTRIAFOL	Fungicide	Rhyme					703	703			6,183	6,183	0%	0%	16%	5%
FLUXAPYROXAD	Fungicide	fluxapyroxad/ pyraclostrobin: Merivon	Conventional		1,107	1,781	4,900	2,596	6,410	10,351	28,119	14,960	15%	26%	74%	38%
FOSETYL-AL	Fungicide	Aliette WDG	Conventional		3,149	1,970	2,750	2,623	869	624	715	736	2%	2%	2%	2%
GLOCLADIUM VIRENS GL-21 (SPORES)	Fungicide	SoilGard	Organic		188	221	329	246	284	283	314	294	1%	1%	1%	1%
GLUFOSINATE-AMMONIUM	Herbicide						1	1			0	0	0%	0%	0%	0%
GLYPHOSATE, ISOPROPYLAMINE SALT	Herbicide	Alecto 41, Buccaneer, Roundup, Cornerstone Plus, Credit Xtreme, CropSMART, Imitator	conventional		2,736	1,731	837	1,768	551	304	435	430	1%	1%	1%	1%
GLYPHOSATE, POTASSIUM SALT	Herbicide				425	300	237	320	842	158	179	393	2%	0%	0%	1%
HEXYTHIAZOX	Acaricide	Savey	Conventional	Two-spotted mites	3,840	3,013	2,537	3,130	20,589	16,240	13,654	16,827	50%	40%	36%	42%
HYDROGEN PEROXIDE	Fungicide	OxiDate	Organic		759	9,804	17,568	9,377	631	3,462	6,121	3,404	2%	9%	16%	9%
IMIDACLOPRID	Insecticide	Admire, Advise, Amtide, Alias, Couraze, Dominion, Imidacloprid	Conventional	whiteflies	6,364	5,146	4,403	5,304	14,291	11,419	9,987	11,899	34%	28%	26%	30%
IPRODIONE	Fungicide	Rovral, Iprodione, Meteor	Conventional		4	132	240	125	8	131	348	162	0%	0%	1%	0%

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
IRON PHOSPHATE	Molluscicide	Bug-N-Sluggo	Organic		70	222	246	180	307	1,271	1,231	936	1%	3%	3%	2%
ISODECYL ALCOHOL	Solvent, Adjuvant						14	14			170	170	0%	0%	0%	0%
ISOPROPYL ALCOHOL	Microbiocide				1,247	737	895	960	21,128	11,035	11,700	14,621	51%	27%	31%	36%
KAOLIN	Insecticide, Fungicide, Microbiocide				166	45		105	5	3		4	0%	0%	0%	0%
KEROSENE	Insecticide, Solvent						0	0			41	41	0%	0%	0%	0%
LECITHIN	Fungicide		Organic		35,520	37,714	33,920	35,718	122,823	119,670	104,773	115,755	296%	295%	276%	289%
LIMONENE	Insecticide					3	90	47		9	7	8	0%	0%	0%	0%
MALATHION	Insecticide	Cheminova, Malathion, Fyfanon,	Conventional	Lygus	84,984	71,873	51,526	69,461	42,902	36,193	26,177	35,090	103%	89%	69%	87%
MANGANESE SULFATE					95	149		122	1,927	3,215		2,571	5%	8%	0%	4%
MARGOSA OIL	Insecticide	Debug Turbo	Organic		6,198	4,311	4,481	4,997	3,747	1,768	3,524	3,013	9%	4%	9%	8%
MEFENOXAM	Fungicide	Ridomil Gold SL, Ultra Flourish	Conventional		5,086	4,639	5,480	5,068	12,776	10,677	12,532	11,995	31%	26%	33%	30%
MEFENOXAM, OTHER RELATED	Fungicide				5		1	3	347		50	199	1%	0%	0%	0%
METALDEHYDE	Molluscicide	Deadline	Conventional	snails	231	226	272	243	414	447	449	437	1%	1%	1%	1%
METAM-SODIUM	Fumigant				229,182	636,036	185,213	350,144	1,197	2,976	912	1,695	3%	7%	2%	4%
METARHIZIUM ANISOPLIAE STRAIN F52	Insecticide	Met 53	Conventional		16	3		9	39	19		29	0%	0%	0%	0%
METHOXYFENOZIDE	Insecticide	Intrepid, Troubadour 2F	Conventional	corn earworm, beet armyworm, LBAM, other leafrollers, cutworms	4,533	3,538	3,721	3,931	25,884	18,940	19,306	21,377	62%	47%	51%	53%
METHYL BROMIDE	Fumigant	methyl bromide/chloropicrin: MBC-33, Tri-con 50/50, Tri-con 57/43, Tri-con 80/20	Conventional		726,076	795,032	633,319	718,142	4,546	5,343	3,933	4,607	11%	13%	10%	12%
METHYL PARATHION	Insecticide, Nematicide						4	4			18	18	0%	0%	0%	0%
METHYL PARATHION, OTHER RELATED	Insecticide, Nematicide						0	0			18	18	0%	0%	0%	0%
METHYLATED SOYBEAN OIL	Insecticide				12,261	14,653	14,935	13,950	29,924	33,899	42,820	35,548	72%	84%	113%	90%
MINERAL OIL	Insecticide	Spray oil	Organic		17,167	8,829	7,010	11,002	83,869	73,271	62,202	73,114	202%	181%	164%	182%
MSMA	Herbicide		Conventional		579	575	339	498	96	127	75	99	0%	0%	0%	0%
MYCLOBUTANIL	Fungicide	Rally, Nova, Sonoma	Conventional		7,990	6,059	5,279	6,443	78,380	56,948	48,519	61,282	189%	141%	128%	152%
NALED	Insecticide	Dibrom	Conventional	Lygus	20,706	19,586	12,651	17,648	20,915	20,070	12,796	17,927	50%	50%	34%	45%
NAPROPAMIDE	Herbicide	Devrinol	conventional		2,555	3,989	4,298	3,614	1,660	1,857	1,525	1,680	4%	5%	4%	4%
NONANOIC ACID	Herbicide				5			5	1			1	0%	0%	0%	0%
NONANOIC ACID, OTHER RELATED	Herbicide				0			0	1			1	0%	0%	0%	0%
NOVALURON	Insecticide	Rimon, Diamond	Conventional	Lygus	5,053	6,242	5,635	5,643	67,298	81,935	74,865	74,699	162%	202%	198%	187%
OXYFLUORFEN	Herbicide	Goal, Double O	conventional		3,499	2,529	2,664	2,897	11,823	8,384	7,972	9,393	28%	21%	21%	23%
PAECILOMYCES FUMOSOROSEUS APOPKA STRAIN 97	Insecticide	PFR-97, Preferal	Organic		532	79	223	278	1,494	201	562	752	4%	0%	1%	2%

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
PARAQUAT DICHLORIDE	Herbicide				198	148	227	191	220	230	232	227	1%	1%	1%	1%
PARATHION	Herbicide						0	0			4	4	0%	0%	0%	0%
PARATHION, OTHER RELATED	Herbicide						-	-			4	4	0%	0%	0%	0%
PENDIMETHALIN	Herbicide	Pendulum, Prowl, Satellite, Up-End HydroCap	conventional		12,803	11,557	13,161	12,507	10,457	10,029	10,590	10,359	25%	25%	28%	26%
PENTHIOPYRAD	Fungicide	Fontelis	Conventional		9,834	10,161	9,550	9,848	33,754	34,438	32,395	33,529	81%	85%	85%	84%
PEROXYACETIC ACID	Fungicide	peroxyacetic acid/ hydrogen peroxide: Jet-Ag, Rendition, Oxidate 2.0, Terraclean	Organic		96	1,522	1,733	1,117	497	3,416	5,498	3,137	1%	8%	15%	8%
PETROLEUM DISTILLATES, ALIPHATIC	Insecticide, Herbicide					1	10	5		171	1,228	699	0%	0%	3%	1%
PETROLEUM DISTILLATES, AROMATIC	Insecticide, Herbicide				121	90	73	95	375	247	300	307	1%	1%	1%	1%
PETROLEUM DISTILLATES, REFINED	Insecticide, Herbicide				2,842	2,219	392	1,818	381	480	56	305	1%	1%	0%	1%
PETROLEUM NAPHTHENIC OILS	Insecticide					7	112	59		171	1,228	699	0%	0%	3%	1%
PETROLEUM OIL, PARAFFIN BASED	Insecticide	Spray oil - Omni Supreme Spray, Saf-T-Side	Organic		7		42	25	46		97	72	0%	0%	0%	0%
PETROLEUM OIL, UNCLASSIFIED	Insecticide, Herbicide				8		11	9	8		7	8	0%	0%	0%	0%
PHOSPHORIC ACID	Insecticide				3,172	2,522	1,501	2,398	65,044	58,661	48,881	57,528	157%	145%	129%	144%
PIPERONYL BUTOXIDE	Insecticide				9,511	5,179	2,538	5,743	19,632	10,871	5,439	11,981	47%	27%	14%	29%
PIPERONYL BUTOXIDE, OTHER RELATED	Insecticide				2,261	1,258	629	1,383	19,049	10,581	5,389	11,673	46%	26%	14%	29%
POLYBUTENES	Rodenticide				2,720	2,234	2,908	2,621	37,172	33,836	35,286	35,431	90%	84%	93%	89%
POLYHEDRAL OCCLUSION BODIES (OB'S) OF THE NUCLEAR POLYHEDROSIS VIRUS OF HELICOVERPA ZEA (CORN EARWORM)	Insecticide	Gem Star	Organic			1	3	2		307	761	534	0%	1%	2%	1%
POLY-I-PARA-MENTHENE	Insecticide				1,617	283	338	746	4,828	375	1,108	2,103	12%	1%	3%	5%
POLYMERIZED PINENE	Insecticide				24	70	809	301	35	264	919	406	0%	1%	2%	1%
POLYOXIN D, ZINC SALT	Fungicide	Affirm, OSO, Ph-D, Tavano	Conventional		94	118	503	238	4,789	4,229	12,395	7,138	12%	10%	33%	18%
POLYPROPYLENE GLYCOL	Insecticide, Adjuvant				22	14	12	16	3,064	2,041	2,708	2,604	7%	5%	7%	7%
POTASH SOAP	Insecticide	M-Pede, Des-X	Organic		9,813	11,488	5,246	8,849	1,956	2,152	1,190	1,766	5%	5%	3%	4%
POTASSIUM BICARBONATE	Fungicide	Kaligreen, Milstop, Armicarb	Organic		29,675	25,994	14,875	23,515	12,562	11,262	6,269	10,031	30%	28%	17%	25%
POTASSIUM HYDROXIDE	Fungicide, Herbicide, Microbiocide		Conventional		1,774	1,914	1,513	1,734	85,384	85,813	65,399	78,865	206%	212%	173%	197%
POTASSIUM N-METHYLDITHIOCARBAMATE	Fumigant	K-Pam HL, Sectagon-K54	Conventional		228,606	168,347	232,594	209,849	1,264	752	1,042	1,019	3%	2%	3%	3%

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
POTASSIUM PHOSPHITE	Fungicide	ProPhyt, Fungiphite, Rampart, Organocide Plant Doctor	Organic		2,455	2,201	2,714	2,457	907	784	792	828	2%	2%	2%	2%
POTASSIUM SILICATE	Insecticide, Adjuvant, Fungicide	Sil-Matrix	Organic		6	4,572	5,373	3,317	2	1,392	1,664	1,019	0%	3%	4%	3%
PROPICONAZOLE	Fungicide	AmTide, Bumper, Cover, Fitness, Orbit, Propicure, Propicon, Shar-Shield, Tide, Tilt, Topaz Vigil	Conventional		1,479	2,135	1,965	1,860	14,351	18,817	16,879	16,682	35%	46%	45%	42%
PROPIONIC ACID	Herbicide				15,133	14,609	11,783	13,842	98,192	92,389	73,002	87,861	237%	228%	193%	219%
PROPYLENE GLYCOL	Fungicide, Adjuvant, Microbiocide				5,016	4,629	5,473	5,039	71,439	61,820	79,713	70,991	172%	153%	210%	178%
PROPYLENEGLYCOL MONOLAUATE	Acaricide	Acaritouch	Conventional		44			44	76			76	0%	0%	0%	0%
PURPUREOCILLIUM LILACIUNUM STRAIN 251	Nematicide	BioAct WG, MeloCon WG	Organic		1	12	10	8	3	51	40	31	0%	0%	0%	0%
PYRACLOSTROBIN	Fungicide	Cabrio	Conventional		16,556	14,418	14,497	15,157	94,290	78,913	82,113	85,105	227%	195%	217%	213%
PYRETHRINS	Insecticide	Azera, EverGreen Crop Protection, PyGanic, Pyrenone, Tersus	Organic		1,817	1,583	957	1,453	35,061	34,160	20,900	30,040	84%	84%	55%	75%
PYRIMETHANIL	Fungicide	Scala	Conventional		10,903	11,466	9,622	10,664	30,222	32,858	27,432	30,171	73%	81%	72%	75%
PYRIPROXYFEN	Insecticide	Esteem Ant Bait	Conventional	whiteflies	203	147	81	144	3,021	2,241	1,212	2,158	7%	6%	3%	5%
QST 713 STRAIN OF DRIED BACILLUS SUBTILIS	Fungicide	Serenade, Cease	Organic		1,185	1,032	1,122	1,113	9,335	11,331	10,450	10,372	22%	28%	28%	26%
QUILLAJA	Fungicide, Nematicide		Organic				1	1			50	50	0%	0%	0%	0%
QUINOXYFEN	Fungicide	Quintec	Conventional		5,359	4,907	4,832	5,033	57,203	52,928	51,562	53,898	138%	131%	136%	135%
REYNOUTRIA SACHALINENSIS	Fungicide	Regalia	Organic		2,028	2,399	2,679	2,369	10,810	12,005	12,882	11,899	26%	30%	34%	30%
ROTENONE	Insecticide		Organic				0	0			7	7	0%	0%	0%	0%
ROTENONE, OTHER RELATED	Insecticide		Organic				0	0			7	7	0%	0%	0%	0%
SAPONIN	Insecticide		Organic		10	13	11	12	78	105	84	89	0%	0%	0%	0%
SODIUM BICARBONATE	Fungicide				35	4		20	108	174		141	0%	0%	0%	0%
SODIUM CARBONATE	Fungicide, Microbiocide, Herbicide				1			1	38			38	0%	0%	0%	0%
SODIUM HYPOCHLORITE	Microbiocide					0	0	0		55	1	28	0%	0%	0%	0%
SODIUM METASILICATE	Insecticide, Adjuvant, Fungicide				0			0	38			38	0%	0%	0%	0%
SOYBEAN OIL	Insecticide	Golden Pest Spray Oil	Organic		74	38	5	39	12	27	8	15	0%	0%	0%	0%
SPINETORAM	Insecticide	Radiant, Delegate	Conventional	thrips, corn earworm	3,479	3,196	3,336	3,337	52,029	45,603	46,643	48,092	125%	113%	123%	120%

Pesticide Information					a. Pounds of Active Ingredient (AI) Applied				b. Strawberry Crop Acreage Treated and Percentages							
Active Ingredient	Pesticide Type	Trade Name	Organic or Conventional	Target Pests	Pounds Applied, 2014	Pounds Applied, 2015	Pounds Applied, 2016	Pounds Applied, 3-Year	Area Treated, 2014	Area Treated, 2015	Area Treated, 2016	Area Treated, 3-Yr Average	Percent of 2014 CA Acreage	Percent of 2015 CA Acreage	Percent of 2016 CA Acreage	Percent of 2014-2016 CA Acreage
SPINOSAD	Insecticide	Conserve, Success, Entrust, Seduce	Organic	thrips, corn earworm, maybe LBAM	1,233	1,168	1,128	1,176	15,237	13,073	13,063	13,791	37%	32%	34%	34%
SPIROMESIFEN	Acaricide	Oberon 3	Conventional	Two-spotted mites	5,046	3,383	2,775	3,734	21,785	13,894	11,276	15,652	52%	34%	30%	39%
SPIROTETRAMAT	Insecticide	Movento				0		0		2		2	0%	0%	0%	0%
STARCH						0	0	0		126	228	177	0%	0%	1%	0%
STREPTOMYCES LYDICUS WYEC 108	Fungicide	Actinovate	Organic		0	1	1	1	2,625	4,066	4,686	3,793	6%	10%	12%	10%
SUCROSE OCTANOATE						0		0		1		1	0%	0%	0%	0%
SULFENTRAZONE	Herbicide	Zeus	conventional		82	157	255	165	428	727	1,269	808	1%	2%	3%	2%
SULFUR	Fungicide, Insecticide, Nematicide, Acaricide	Various	Organic		933,438	793,771	621,504	782,904	263,699	217,439	176,954	219,364	635%	537%	467%	546%
SULFURIC ACID					0			0	2			2	0%	0%	0%	0%
TETRACONAZOLE	Fungicide	Mettle	Conventional		1,065	1,061	943	1,023	27,345	27,152	24,022	26,173	66%	67%	63%	65%
TETRAPOTASSIUM PYROPHOSPHATE	Fungicide, Herbicide, Microbiocide				73	52	36	54	7,350	4,067	2,994	4,804	18%	10%	8%	12%
THIAMETHOXAM	Insecticide, Nematicide, Acaricide	Actara, Platinum, Voliam	Conventional	Lygus, aphids	1,505	1,883	966	1,451	24,564	30,918	15,535	23,672	59%	76%	41%	59%
THIOPHANATE	Fungicide		Conventional			4	18	11		5	25	15	0%	0%	0%	0%
THIOPHANATE-METHYL	Fungicide	Topsin, Topsin M, Incognito, Cercobin, T-Methyl	Conventional		9,138	8,439	7,865	8,481	13,173	11,909	11,315	12,133	32%	29%	30%	30%
THIRAM	Fungicide	Thiram (65WSB, Granuflo, 65)	Conventional		19,750	25,871	22,308	22,643	10,203	12,145	9,986	10,778	25%	30%	26%	27%
TRICHODERMA HARZIANUM RIFAI STRAIN KRL-AG2	Fungicide	RootShield WP	Organic			0	0	0		9	6	7	0%	0%	0%	0%
TRICHODERMA ICC 012 ASPERELLUM	Fungicide	TrichoSym	Organic			1	9	5		135	159	147	0%	0%	0%	0%
TRICHODERMA ICC 080 GAMSII	Fungicide	Bio-Tam, Tenet	Organic			1	9	5		135	159	147	0%	0%	0%	0%
TRICHODERMA VIRENS STRAIN G-41	Fungicide	Rootmate	Organic			0	0	0		7	6	7	0%	0%	0%	0%
TRIETHANOLAMINE	Adjuvant, Microbiocide, Insecticide				187	132	93	137	7,350	4,067	2,994	4,804	18%	10%	8%	12%
TRIFLOXYSTROBIN	Fungicide	Flint	Conventional		798	637	1,927	1,121	9,057	6,683	17,212	10,984	22%	17%	45%	28%
TRIFLUMIZOLE	Fungicide	Procure	Conventional		8,993	8,950	8,052	8,665	36,354	38,846	33,808	36,336	88%	96%	89%	91%
UREA	Microbiocide, Fungicide				6			6	105			105	0%	0%	0%	0%
UREA DIHYDROGEN SULFATE	Herbicide						0	0			6	6	0%	0%	0%	0%
XYLENE	Solvent, Microbiocide		Conventional		1	133	3	46	75	556	10	214	0%	1%	0%	1%
XYLENE RANGE AROMATIC SOLVENT	Solvent, Insecticide		Conventional		0		0	0	80		4	42	0%	0%	0%	0%
ZINC SULFATE	Microbiocide, Herbicide		Conventional		155	231		193	2,065	3,215		2,640	5%	8%	0%	4%

APPENDIX 10. Maximum Residue Levels for Strawberries

Strawberry	United States	Canada	China	Codex	European Union	Hong Kong	Japan	Korea	Mexico	Taiwan	United Arab Emirates	United Kingdom
2,4-D	0.05	0.05	0.1	0.1	0.1	0.1	0.05	0.05 Expires Dec 31, 2021	0.05 (US)	0.1	0.1 (Codex)	0.1 (EU)
Abamectin	0.05	0.05	{0.02}	0.15	0.15	{0.02}	0.2	0.1	{0.02}	{0.02}	0.15 (Codex)	0.15 (EU)
Acequinocyl	0.5	0.5	---	---	{0.01}	{0.4}	2	1	{0.4}	{0.01}	{0.01} (EU)	{0.01} (EU)
Acetamiprid	0.6	0.6 {0.1}	2	{0.5}	{0.5}	3	3	1	0.6 (US)	1	{0.5} (Codex)	{0.5} (EU)
Acibenzolar-S-methyl	0.15	Default	---	0.15	0.15	---	0.2	{0.01} Default	0.15 (US)	{0.01}	0.15 (Codex)	0.15 (EU)
Acifluorfen	0.05	0.1 Default	---	---	{0.01} Default	---	{0.01} Default	{0.01} Default	0.05 (US)	---	{0.01} Default	{0.01} (EU) Default
Aldrin	0.05	0.1 Default	0.05	---	{0.01}	0.05	{0.01} Default	{0.01} Default	0.05 (US)	{0.01}	{0.01} Default	{0.01} (EU)
Aluminum phosphide	-- 0.01 Processed food	0.1 Default	---	---	0.01	---	0.01 0.01 Default Fruits, dried	0.01 Default 0.1	-- 0.01 Processed food (US)	---	0.01 Default	0.01 (EU)
Azoxystrobin	10	10	---	10	10	10	10	{1}	10	{2}	10 (Codex)	10 (EU)
Benoxacor	0.01	0.01	---	---	---	---	0.01 Default	0.01 Default	0.01 (US)	---	0.01 Default	---
Bifenazate	1.5	1.5	2	2	3	---	5	{1}	1.5	2	2 (Codex)	3 (EU)
Bifenthrin	3	{0.1} Default	{1}	---	{1}	{1}	{2}	{0.5}	3	{2}	{0.01} Default	{1} (EU)
Boscalid	4.5	4.5	{3}	{3}	6 3	{3}	15	5	{1.2}	{3}	{3} (Codex)	6 (EU) 3 (EU)
Buprofezin	2.5	3	---	3	Pending 0.01 Aug 13, 2019	3	3	{0.01} Default	2.5 (US)	{0.01}	3 (Codex)	Pending 0.01 Aug 13, 2019
Buprofezin	20	{5}	{15}	{15}	{1.5}	{15}	{15}	{5} {0.5}	25	{8}	{15} (Codex)	{1.5} (EU)
Carbaryl	4	7	---	---	{0.01}	4	7	Expires Dec 31, 2021 {0.01}	10	{0.5}	{0.01} Default	{0.01} (EU)
Carfentrazone-ethyl	0.1	0.1	---	---	{0.01}	0.1	0.1	{0.01} Default	0.1 (US)	{0.01}	{0.01} (EU)	{0.01} (EU)
Chlorantraniliprole	1	1	1	1	1	1	1	1	1 (US)	1	1 (Codex)	1 (EU)
Chlordane	0.1	0.1 Default	{0.02}	{0.02}	{0.01}	{0.02}	{0.02}	{0.02} Expires Dec 31, 2021	0.1 (US)	{0.01}	{0.01} Default	{0.01} (EU)
Chlorpyrifos	0.2	{0.1} Default	---	0.3	0.3	0.3	0.2	Expires Dec 31, 2021 {0.01}	0.2 (US)	1	{0.01} Default	0.3 (EU)
Clethodim	3	{0.1} Default	---	---	{0.5}	---	{0.01} Default	{0.05}	3 (US)	{0.01}	{0.5} (EU)	{0.5} (EU)
Clopyralid	4	{1}	---	---	{0.5}	4	{1}	{0.01} Default	4 (US)	---	{0.5} (EU)	{0.5} (EU)
Cryolite	7	{0.1} Default	---	---	{0.01} Default	7	{0.01} Default	{0.01} Default	7 (US)	---	{0.01} Default	{0.01} (EU) Default
Cyantraniliprole	1	{0.1} Default	---	---	{0.5}	---	1	{0.7}	1 (US)	---	{0.5} (EU)	{0.5} (EU)
Cyflufenamid	0.2	0.2	---	---	{0.04}	---	0.7	0.5	0.2 (US)	0.5	{0.04} (EU)	{0.04} (EU)
Cyflumetofen	0.6	0.6	---	0.6	0.6	---	2	1	0.6 (US)	2	0.6 (Codex)	0.6 (EU)
Cyprodinil	5	6	{2}	10	5	5	5	{1}	5	5	10 (Codex)	5 (EU)
DCPA	2	2	---	---	{0.01}	2	2	{0.01} Default	2	{0.01}	{0.01} (EU)	{0.01} (EU)
DDT (DDE, DDD)	0.1	0.1 Default	{0.05}	---	{0.05}	{0.05}	0.2	{0.01} Default	0.1 (US)	{0.01}	{0.01} Default	{0.05} (EU)
Diazinon	0.5	0.75	{0.1}	{0.1}	{0.01}	{0.1}	{0.1}	{0.01} Default	0.5	0.5	{0.01} Default	{0.01} (EU)
Dichlormid	0.05	0.1 Default	---	---	{0.01} Default	---	{0.01} Default	{0.01} Default	0.05 (US)	---	{0.01} Default	{0.01} (EU) Default
Dichlorvos	-- 0.5 Packed or bagged nonperishable processed food	0.1 Default	0.2	---	0.01	0.2	0.3	0.05 Expires Dec 31, 2021	-- 0.5 Packed or bagged nonperishabl e processed	0.01	0.01 Default	0.01 (EU)

APPENDIX 10 (cont'd). Maximum Residue Levels for Strawberries

Strawberry	United States	Canada	China	Codex	European Union	Hong Kong	Japan	Korea	Mexico	Taiwan	United Arab Emirates	United Kingdom
Dieldrin	0.05	0.1 Default	{0.02}	--	{0.01}	0.05	{0.01} Default	{0.01} Default	0.05 (US)	{0.01}	{0.01} Default	{0.01} (EU)
Difenoconazole	2.5	2.5	--	{2}	{0.5} Pending 2 Apr 25, 2019	5	{2}	{0.5}	2.5 (US)	{1}	{2} (Codex)	{0.5} (EU) Pending 2 Apr 25, 2019
Dimethomorph	0.9	{0.1} Default	{0.05}	{0.5}	{0.7}	{0.05}	{0.05}	2	0.9 (US)	2	{0.5} (Codex)	{0.7} (EU)
Diquat dibromide	0.05	0.1 Default	--	0.05	0.05	--	{0.03}	{0.01} Default	0.05 (US)	--	{0.01} Default	0.05 (EU)
Dodine	5	5	--	--	{0.01}	5	{3}	Expires Dec 31, 2024	5 (US)	--	{0.01} (EU)	{0.01} (EU)
Etofenprox	5	{0.1} Default	--	--	{1} Pending 0.01 Aug 13, 2019	--	{0.01} Default	{1}	5 (US)	{0.01}	{1} (EU)	{1} (EU) Pending 0.01 Aug 13, 2019
Etoxazole	0.5	0.5	--	--	{0.2}	--	0.5	0.5	0.5	0.5	{0.2} (EU)	{0.2} (EU)
Fenazaquin	2	{0.1} Default	--	--	{1}	--	{0.01} Default	{0.7}	2 (US)	{0.1}	{1} (EU)	{1} (EU)
Fenbutatin-oxide	10	{0.1} Default	10	10	{1} Pending 0.01 Aug 13, 2019	10	10	{3}	10	{0.01}	{0.01} Default	{1} (EU) Pending 0.01 Aug 13, 2019
Fenhexamid	3	3	10	10	10	10	10	{2}	3	{0.01}	10 (Codex)	10 (EU)
Fenpropathrin	2	2	5	2	2	5	5	{0.5}	2	{1}	{0.01} Default	2 (EU)
Fenpyrazamine	3	3	--	3	3	--	10	{2}	3 (US)	--	3 (Codex)	3 (EU)
Fenpyroximate	1	1	--	{0.3}	{0.3}	--	{0.5}	{0.5}	1 (US)	{0.5}	{0.3} (Codex)	{0.3} (EU)
Fonicamid	1.5	1.5	--	1.5	{0.03}	--	2	{1}	1.5 (US)	{0.01}	1.5 (Codex)	{0.03} (EU)
Fluazifop-P-butyl	3	{1}	--	{0.3}	{0.3}	--	{0.01} Default	{0.01} Default	3 (US)	{0.01}	{0.3} (Codex)	{0.3} (EU)
Flubendiamide	1.5	1.5 Import Tolerance	--	--	{0.2}	2	2	{1}	1.5 (US)	{1}	{0.2} (EU)	{0.2} (EU)
Fludioxonil	3	3	--	3	4	3	5	{2}	3 (US)	{2}	3 (Codex)	4 (EU)
Fluensulfone	0.3	{0.1} Default	--	0.5	{0.01} Default	--	0.3	{0.01} Default	0.3 (US)	0.3	0.5 (Codex)	{0.01} (EU) Default
Flumioxazin	0.07	0.07	--	--	{0.02}	0.07	0.07	{0.01} Default	0.07 (US)	--	{0.02} (EU)	{0.02} (EU)
Fluopyram	2	2	--	{0.4}	2	--	5	3	2 (US)	{0.4}	{0.4} (Codex)	2 (EU)
Fluoride	-- 70 All processed food commodities not otherwise listed	0.1 Default	--	--	2	--	0.01 Default	0.01 Default	-- 70 All processed food commodities	--	0.01 Default	2 (EU)
Fluoxastrobin	1.9	1.9	--	--	{0.01}	--	2	{0.01} Default	1.9 (US)	--	{0.01} (EU)	{0.01} (EU)
Flupyradifurone	1.5	1.5	--	1.5	{0.4}	--	2	1.5 Import Tolerance	1.5 (US)	{1}	1.5 (Codex)	{0.4} (EU)
Flutianil	0.5	{0.1} Default	--	--	{0.01} Default	--	0.5	{0.3}	0.5 (US)	--	{0.01} Default	{0.01} (EU) Default
Flutriafol	1.5	1.5	{1}	1.5	1.5	--	{0.01} Default	{0.01} Default	1.5 (US)	{0.01}	1.5 (Codex)	1.5 (EU)
Fluxapyroxad	4	4	--	7	4	--	7	{2}	4 (US)	{2}	7 (Codex)	4 (EU)
Folpet	5 Import Tolerance	25	5	5	5	5	5	{3}	25	--	{0.01} Default	5 (EU)
Fomesafen	0.02	0.02	--	--	{0.01}	--	{0.01} Default	{0.01} Default	0.02 (US)	--	{0.01} (EU)	{0.01} (EU)
Fosetyl-AI	75	75	--	{70}	75 Pending 100 Apr 25, 2019	75	75	Expires Dec 31, 2024	75	75	{0.01} Default	75 (EU) Pending 100 Apr 25, 2019

APPENDIX 10 (cont'd). Maximum Residue Levels for Strawberries

Strawberry	United States	Canada	China	Codex	European Union	Hong Kong	Japan	Korea	Mexico	Taiwan	United Arab Emirates	United Kingdom
Glyphosate	0.2	{0.1} Default	{0.1}	---	{0.1}	0.2	0.2	{0.01} Default	0.2 (US)	0.2	{0.1} (EU)	{0.1} (EU)
Heptachlor	0.05	0.1 Default	{0.01}	---	{0.01}	{0.01}	{0.01} Default	{0.01} Default	0.05 (US)	{0.01}	{0.01} Default	{0.01} (EU)
Hexachlorobenzene	0.05	0.1 Default	---	---	{0.01}	---	{0.01}	{0.01} Default	0.05 (US)	---	{0.01} Default	{0.01} (EU)
Hexythiazox	6	6	{0.5}	6	{0.5}	{0.5}	6	{1}	{3}	{1}	6 (Codex)	{0.5} (EU)
Imidacloprid	0.5	0.5	---	0.5	0.5	0.5	{0.4}	{0.4} Import Toleranc	0.5	1	0.5 (Codex)	0.5 (EU)
Iprodione	15	{5} Expires Jun 21, 2022	---	{10}	20 Pending 0.01 Jul 31, 2019	{10}	20	{10}	15	{5}	{10} (Codex)	20 (EU) Pending 0.01 Jul 31, 2019
Isofetamid	4	4	---	4	4	---	4 Import Toleranc	{3}	4 (US)	---	4 (Codex)	4 (EU)
Lindane	0.5	{0.1} Default	---	---	{0.01}	---	2	{0.01} Default	0.5 (US)	{0.01}	{0.01} Default	{0.01} (EU)
Magnesium phosphide	0.01 Processed food	0.1 Default	---	---	0.01	---	0.01 0.01 Fruits, dried	{0.01} Default	0.01 Processed food (US)	---	0.01 Default	0.01 (EU)
Malathion	8	8	{1}	{1}	{0.02}	{1}	{1}	{0.01} Expires Dec 31, 2021	8	{1}	{0.01} Default	{0.02} (EU)
Mandestrobin	3	3	---	---	{0.01}	---	3	{0.01} Default	3 (US)	---	{0.01} (EU)	{0.01} (EU)
Mepanipyrim	1.5 Import Tolerance	{0.1} Default	---	---	3	---	10	3	1.5 (US)	{1}	3 (EU)	3 (EU)
Metalaxyl	10	10	---	---	{0.6}	---	{7}	{0.2} Expires Dec 31, 2021	10 (US)	{5}	{0.01} Default	{0.6} (EU)
Metalaxyl-M (Mefenoxam)	10	10	---	---	{0.6}	---	{7}	{0.01} Default	10 (US)	{5}	{0.01} Default	{0.6} (EU)
Metalddehyde	6.25	{0.15}	---	---	{0.05}	6.25	{0.7}	{0.01} Default	6.25 (US)	---	{0.01} Default	{0.05} (EU)
Methoxyfenozide	2	2	---	2	2	2	2	{0.7}	2 (US)	2	2 (Codex)	2 (EU)
Methyl bromide	60 * 125 Processed food other than those listed	{0.1} Default	{30}	{30}	{30}	{30}	{30} 30 Fruits, dried	{0.01} Default 30 Dried fruits	{5} * (US) US Section 18: Expires Dec 31, 2020 125	---	{0.01} Default	{30} (EU)
Myclobutanil	0.5	0.5	1	0.8	1	1	1	1	0.5 (US)	0.5	{0.01} Default	1 (EU)
Naled	1	1	---	---	{0.01} Default	1	{0.3}	{0.01} Default	1	---	{0.01} Default	{0.01} (EU) Default
Napropamide	0.1	0.1	---	---	0.2	0.1	0.1	{0.05}	0.1	{0.01}	0.2 (EU)	0.2 (EU)
Novaluron	0.45	0.45	0.5	0.5	0.5	0.5	2	1	0.45 (US)	0.5	0.5 (Codex)	0.5 (EU)
Oryzalin	0.05	0.1 Default	---	---	{0.01}	0.05	0.1	{0.01} Default	0.05 (US)	---	{0.01} (EU)	{0.01} (EU)
Oxydemeton-methyl	2	{0.1} Default	---	---	{0.01}	---	{1}	{0.01} Default	2	{0.01}	{0.01} Default	{0.01} (EU)
Paraquat dichloride	0.25	{0.1} Default	{0.01}	{0.01}	{0.02}	{0.01}	{0.05}	{0.01} Default	0.25 (US)	{0.01}	{0.01} Default	{0.02} (EU)
Pendimethalin	0.1	0.1 Default	---	---	{0.05}	---	{0.05}	{0.05}	0.1 (US)	{0.01}	{0.05} (EU)	{0.05} (EU)
Penthiopyrad	3	3	---	3	3	---	3	{1}	3 (US)	3	3 (Codex)	3 (EU)

APPENDIX 10 (cont'd). Maximum Residue Levels for Strawberries

Strawberry	United States	Canada	China	Codex	European Union	Hong Kong	Japan	Korea	Mexico	Taiwan	United Arab Emirates	United Kingdom
Phosphine	-- 0.01 Processed food	0.1 Default 0.01 All	---	---	0.01	---	0.01 0.01 Fruits, dried	0.01 Default 0.1 Dried fruits	-- 0.01 Processed food (US)	---	0.01 Default	0.01 (EU)
Prohexadione calcium	0.3	0.3	---	---	{0.15}	---	2	{0.01} Default	0.3 (US)	---	{0.15} (EU)	{0.15} (EU)
Propiconazole	1.3	1.3	---	---	{0.01}	---	{1}	{0.01} Default	1.3 (US)	{1}	{0.01} (EU)	{0.01} (EU)
Pyraclostrobin	1.2	1.2	---	1.5	1.5	{0.5}	2	{1}	1.2	{0.5}	1.5 (Codex)	1.5 (EU)
Pyridaben	2.5	{2}	---	---	{1} Pending 0.9 Aug 13, 2019	2.5	{2}	{1}	2.5 (US)	{1}	{1} (EU)	{1} (EU) Pending 0.9 Aug 13, 2019
Pyrimethanil	3	3	3	3	5	3	10	{2}	3	3	3 (Codex)	5 (EU)
Pyriofenone	0.5	0.5	---	---	{0.01} Default	---	2	2	0.5 (US)	---	{0.01} Default	{0.01} (EU) Default
Pyriproxyfen	0.3	0.3	---	---	{0.05}	0.3	0.3	1	0.3 (US)	0.5	{0.05} (EU)	{0.05} (EU)
Quinoxifen	1	1	1	1	{0.3}	1	1	{0.01} Default	1 (US)	1	1 (Codex)	{0.3} (EU)
Sethoxydim	10	10	---	---	{0.5}	---	10	{0.05}	10	10	{0.5} (EU)	{0.5} (EU)
Simazine	0.25	{0.1} Default	---	---	{0.01}	0.25	{0.2}	0.25 Expires Dec 31, 2024	0.25	{0.01}	{0.01} Default	{0.01} (EU)
S-metolachlor	0.4	{0.1}	---	---	{0.05}	---	{0.01} Default	{0.01} Default	0.4 (US)	{0.01}	{0.05} (EU)	{0.05} (EU)
Spinetoram	0.9	{0.7}	---	{0.15}	{0.2}	---	2	{0.2}	0.9 (US)	1	{0.15} (Codex)	{0.2} (EU)
Spinosad	0.9	{0.7}	---	---	{0.3}	1	1	1	1	1	{0.3} (EU)	{0.3} (EU)
Spiromesifen	2	2	---	3	{1}	---	2	{1}	2	{1}	3 (Codex)	{1} (EU)
Spirotetramat	0.4 Import Tolerance	0.4	---	---	0.4	---	10	3	0.4 (US)	{0.01}	0.4 (EU)	0.4 (EU)
Sulfentrazone	0.15	0.15	---	---	{0.01} Default	---	0.6	{0.01} Default	0.15 (US)	---	{0.01} Default	{0.01} (EU) Default
Sulfoxaflor	0.7	0.7	---	{0.5}	{0.5}	---	{0.5}	{0.5}	0.7 (US)	{0.5}	{0.5} (Codex)	{0.5} (EU)
Sulfuryl fluoride	-- 2 All processed food commodities not otherwise listed	0.1 Default 2 All processed foods (other than those	---	---	0.01	---	0.01 Default	0.01 Default	-- 2 All processed food commodities not otherwise listed (US)	---	0.01 Default	0.01 (EU)

APPENDIX 10 (cont'd). Maximum Residue Levels for Strawberries

Strawberry	United States	Canada	China	Codex	European Union	Hong Kong	Japan	Korea	Mexico	Taiwan	United Arab Emirates	United Kingdom
Terbacil	0.1	0.1	--	--	{0.01} Default	--	0.1	{0.01} Default	0.1 (US)	--	{0.01} Default	{0.01} (EU) Default
Tetraconazole	0.25	0.25	--	--	{0.2}	--	2	1	0.25 (US)	0.5	{0.2} (EU)	{0.2} (EU)
Thiabendazole	5 Import Tolerance	{0.1} Default	--	--	{0.01}	--	{3}	{0} Expires Dec 31, 2024	5	5	{0.01} (EU)	{0.01} (EU)
Thiamethoxam	0.3	0.3	--	0.5	0.3	0.5	2	1	0.3 (US)	0.5	0.5 (Codex)	0.3 (EU)
Thiophanate-methyl	7	{5}	--	{1}	{0.1}	{1}	{3}	{2}	{5}	{3}	{1} (Codex)	{0.1} (EU)
Thiram	13	{7}	--	{5}	{10}	{5}	{5}	{0} Expires Dec 31, 2024	{7}	{5}	{0.01} Default	{10} (EU)
Tolfenpyrad	3	{0.1} Default	--	--	{0.01} Default	--	3	{0.01} Default	3 (US)	{0.01}	{0.01} Default	{0.01} (EU) Default
Trifloxystrobin	1.5	{1.1}	{1}	{1}	{1} {0.2}	{0.2}	{1}	{0.7}	1.5 (US)	{1}	{1} (Codex)	{1} (EU) {0.2} (EU)
Triflumizole	2	2	--	--	Pending 0.02 May 01, 2040	2	{1}	2	2	{1}	{0.2} (EU)	Pending 0.02 May 01, 2040
Ziram	7	7	--	{5}	{0.1}	{5}	{5}	{0} Expires Dec 31, 2024	7 (US)	{5}	{5} (Codex)	{0.1} (EU)

From Global MRL Database on 04.18.19. Only showing MRLs for AIs with a corresponding US MRL.

APPENDIX 11. Members of the California Strawberry Work Group

Participant Name	Role	Working Group
Henry S. Gonzales	Ag Commissioner, Ventura County	Oxnard
Alma Cangelosi	Ag Commissioners Office, Santa Barbra County	Santa Maria
Gerald Holmes	Cal Poly Strawberry Center, Director	All
Marianna Castiaux	CSC	Oxnard
Mark Edsall	CSC	Oxnard
Marla Livengood	CSC	All
Daniel Olivier	CSC	Santa Maria
Ariel Zajdband	CSC Staff	Watsonville
Philip Espinoza	CSC, Intern	Santa Maria
Zak Ferguson	CSC, Intern	Santa Maria
Rick Tomlinson	CSC, President	Watsonville
Dan Legard	CSC, VP of Reserch	Watsonville
Bob Boelts	Grower	Oxnard
Bobby Jones	Grower	Oxnard
Dave Murray	Grower	Oxnard
Dave Peck	Grower	Santa Maria
Pat Williams	Grower	Santa Maria
Patrick Sheehy	Grower	Santa Maria
Will Doyle	Grower	Oxnard
Kevin Gee	Growers	Santa Maria
Stephen Flanagan	IR-4 Staff	Watsonville
Dan Schmida	PCA	Watsonville
Daniel Ibarra	PCA	Santa Maria
Eduardo Garcia	PCA	Santa Maria
James Reiman	PCA	Oxnard
Lorenzo London	PCA	Watsonville
Patricia Dingus	PCA	Oxnard
Randy Widerburg	PCA	Santa Maria
Jim Wells	Plan Consultant, ESG	All
Andrew Wiemers	Processor, Sunrise	Oxnard
Regulator	Regulator	Watsonville
Brian Leahy	Regulator, DPR Director	Watsonville
Hillary Thomas	Shipper, Naturipe	Watsonville
Rod Koda	Shipper, Co-op	Watsonville
Chris Jenkins	Shipper, Driscoll's	Santa Maria
Kevin Healy	Shipper, Driscoll's	Watsonville
Milton Bardmess	Shipper, Driscoll's	Oxnard
Narded Eguiluz	Shipper, Driscoll's	Santa Maria
Nishan Moutafian	Shipper, Driscoll's	Oxnard
Sean Stevens	Shipper, WelPict	Oxnard
Alexander Putman	University & Extension staff	Oxnard
Anna D. Howell	University & Extension staff	Oxnard
Judit Arno	University & Extension staff	Watsonville
Frank Zalom	University & Extension staff, Professor and Extension Entomologist	Watsonville
Mark Bolda	University & Extension staff, University of California Cooperative Extension Santa Cruz	Watsonville
JoJi Muramoto	University & Extension staff, Associate Researcher	Watsonville
Steve Fennimore	University & Extension staff, Department of Plant Sciences	Watsonville
Matt Baur	Western Region IPM Center, Assoc. Director	Watsonville
Amanda Crump	Western Region IPM Center, Director	Watsonville