

## Survey of High Tunnel Practices in Northern New England, 2016 & 2019

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High tunnels are rudimentary hoop houses covered with one-two layers of plastic, and vented with roll-up sides for cooling. These structures are important tools for Northeastern diversified farmers, offering opportunities for extending the growing season and generating greater revenues by protecting both cold-tolerant crops in winter and high value warm-season crops in all other season. Limited data are available on the number of high tunnels in operation or the acreage they cover, and the practices used within these tunnels.

A survey of Northern New England high tunnel growers was conducted in 2016 to generate baseline data on use of pest, nutrient, and crop management practices. A primary goal was to identify areas where growers were experiencing crop losses AND where educational or research activities could help reduce these losses. In 2019, we conducted a followup survey to learn how the situation changed after three years of intensive high tunnel research and outreach activities under the auspices of our Northeast SARE Project "Improving nutrient and pest management in high tunnel production." To permit direct comparison, the 2019 survey was identical to the 2016 survey *with the exception of* three questions added to the 2019 survey to directly measure project participation and impacts.

In both 2016 and 2019, 110 people responded to our survey, which was distributed via electronic grower newsletters in Maine, New Hampshire, Vermont and Massachusetts. The 2019 survey is available at the following link: <https://unh.box.com/s/hnwnx5az221qtk3dm9jmeyh2zrd0d9q>.

**Here, we present the 2019 results, and compare them with baseline data obtained in 2016.**

### **Executive Summary – changes observed (pg. 2)**

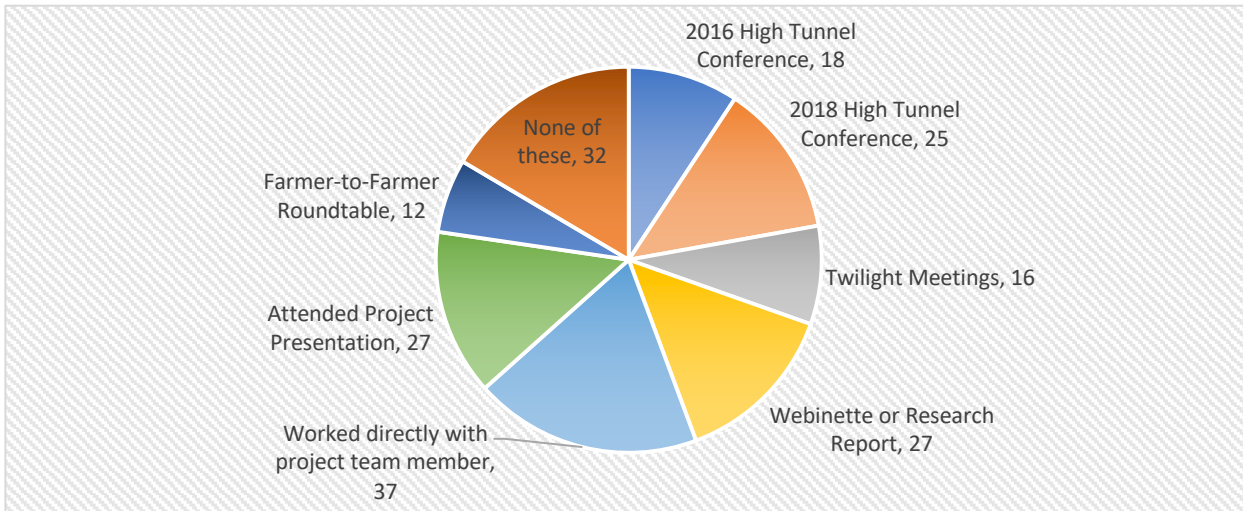
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## Executive Summary – Changes Observed

In general, survey results showed remarkably consistency between 2016 and 2019. While in some ways this is unsurprising (presumably, many of the same growers responded); this consistency provides some verification of the validity of responses. There were a few noteworthy changes between 2016 and 2019; which may be chance shifts based on varying respondents, or which may be indicative of longer-term shifts in the production situation and challenges.

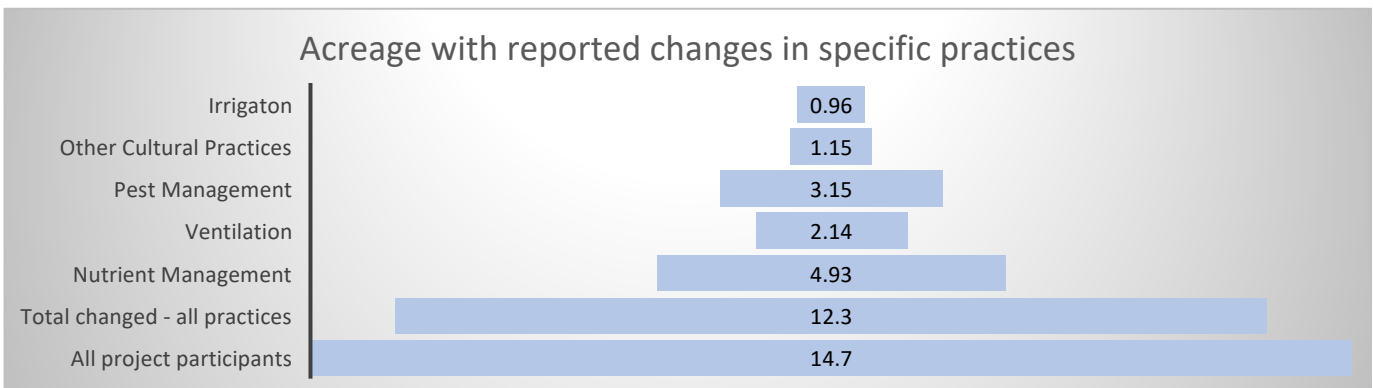
- Crops in high tunnels – Warm-season crops predominate in spring, summer and fall high tunnels, while spinach and greens predominate in winter tunnels. In 2019, eggplants (in summer) increased in popularity, as did cut flowers and ginger (in summer and fall). Greens (in summer) fell slightly. Growers mentioned continuing to produce transplants into the fall and winter, as well as in spring and summer.
- Pests & disease challenges in high tunnels – Among pests, **aphids, striped cucumber beetle, and tomato hornworm** were consistently cited as most frequently causing mild, moderate or severe problems. Among diseases, **tomato leaf mold, powdery mildew and gray mold** were the most challenging. The proportion of growers citing moderate or severe problems caused by **basil downy mildew** increased in 2019.
- Pest & disease management tactics used - In 2019, more growers (>10%) reported using **crop rotation, predators, use of sticky cards, habitat or guardian plants, indicator or trap plants, and beneficial nematodes**, as compared with 2016. This was particularly encouraging, as our research & outreach efforts focused on the use of habitat plants, indicator/trap plants, predators, and sticky cards.
- Pesticide use in tunnels - While growers did report a slight decrease in the use of most categories of pesticides over the past three years (-21%, +3%, -24%, -56%, depending on type), the small numbers of respondents and small numbers of pesticide application in general confirm that growers did, and still do, use relatively few chemical pesticide inputs in their high tunnels.
- Fruit & plant quality issues – Respondents were consistent over time in their ranking of fruit and plant quality issues: fruit cracking, yellow shoulder and blossom end rot were cited as the most frequent disorders; and most felt that they reduced marketable yields when they occurred.
- Tomato varieties grown - We observed large shifts in responses to questions about the types of tomato varieties grown in high tunnels. Between 2016 and 2019, the percentage of respondents that grow at least some **grafted tomatoes** doubled, from around 40% to nearly 80%. The percentage growing exclusively “**modern greenhouse varieties**” increased from around 10% to over 40%. The percentage growing at least some **cherry tomato varieties** fell from 86% to 66%; and the percentage growing at least some **heirloom varieties** fell from 70% to 35%. Possibly related to these changes in types of varieties grown, mean yields increased from 9.5 (in 2016) to 10.4 lbs/plant (in 2019). In both years, a large portion of growers did not know their yields, suggesting an opportunity for improvement.
- Nutrient management strategies - Slightly higher percentages (3-6%, on average) of growers reported soil testing, soluble salts testing, plant leaf tissue analysis, and other nutrient management techniques in 2019 compared with 2016. We also observed a measurable drop (nearly 10% in most cases) in the percentage of growers who *never* leached soluble salts (by removing plastic or by irrigating), tested for soluble salts, or used SME tests. **As a result, it appears that growers are increasingly aware that soluble salts buildup in high tunnels may be a problem that warrants attention.**
- Irrigation management - We observed slight increases in percentage of respondents who use a tensiometer to schedule irrigation events (5% in 2016; 11% in 2019); and who use feel of soil/media to determine when to irrigate (55% in 2016, 68% in 2019). Nearly all respondents felt their irrigation methods were easy to use, but more producers (25-29% in 2016, vs. 34-37% in 2019) said that they *disagreed with or did not know* whether their irrigation strategy resulted in high yields or high quality fruit. **This suggests that growers are less certain that their irrigation strategy is working well for them.**

**1. Impacts of SARE research & education project activities: 2016-2019.** In 2019, 78 out of 110 respondents (71%) reported that they participated in at least one of our project activities during the previous three years. *Working directly with a project team member* was the most frequently mentioned type of participation; but many growers also *attended presentations by project team members, watched webinettes or read research reports, and attended the 2016 and 2018 High Tunnel Conferences.*



Of the 79 respondents that participated in at least one of our SARE project activities, **53 people (68%) reported that they made changes to their farming operation specifically as a result of things they learned at project activities.**

Overall, the 2019 survey respondents reporting growing in tunnels covering 758,454 square feet, or 17.4 acres. **Project participants accounted for the overwhelming majority (84.6%) of this acreage (641,664 square feet, 14.7 acres). Changes in production practices were reported for 534,844 square feet (12.3 acres).** Thirty-four growers (64% of those that stated they changed practices) described the specific changes made. These included: improved nutrient management (14 producers, 4.93 acres), ventilation (5 producers, 2.14 acres), pest management (8 producers, 3.15 acres), irrigation (8 producers, 0.96 acres) and other cultural practices (12 producers, 1.15 acres).



**2. General Information/Cropping Practices.** Nearly half (42% in 2016, 25% in 2019) of respondents' tunnels were entirely certified organic, and 51% (2016) and 54% (2019) were entirely conventional. Split operations were the minority (7% in 2016, 1% in 2019).

In 2019, the number of tunnels per respondent ranged from 0 to 20 (compared with 0 to 22 in 2016), with an average of 4.2 (3.4 in 2016) tunnels each. Participants provided ranges of area covered by their high tunnel space. **We estimated that all respondents' 399 tunnels covered 758,454 square feet, or 17.4 acres** (compared with 682,906 square feet and 15.7 acres in 2016).

Distribution of respondents, and tunnels represented.					
2016			2019		
State	% respondents	No. tunnels reported	State	% respondents	No. tunnels reported
ME	20 %	46	ME	36%	95
NH	55 %	188	NH	48%	160
VT	13 %	55	VT	12%	69
MA	8 %	15	MA, RI, NY	3%	15
CT, RI, NY	4 %	7			

Warm-season crops tomato, pepper, and cucurbits (cucumber, summer squash, etc.) and herbs feature prominently in spring, summer and fall high tunnels. Greens are most commonly grown in fall, winter and spring high tunnels. Many growers use high tunnels for early season transplant production in the spring, before transitioning to other crops in summer. Growers also listed over 20 minor crops including brassicas, ornamentals, raspberry, strawberry, beet, turnips, beans, radish, turmeric, garlic, microgreens, sweetpotato and potato.

2016 responses to: "What crops do you grow during each season in your high tunnel?" <i>Most popular entries are listed first, number of responses in parentheses.</i>			
Spring	Summer	Fall	Winter
Greens (48)	Tomato (64)	Greens (45)	Greens (45)
Transplants (46)	Pepper (54)	Tomato (42)	Herbs (8)
Tomato (36)	Cucurbits (53)	Pepper (27)	Alliums (6)
Cucurbits (26)	Herbs (30)	Herbs (20)	
Herbs (21)	Transplants (25)	Cucurbits (20)	
Pepper (19)	Greens (17)		
	Eggplant (13)		

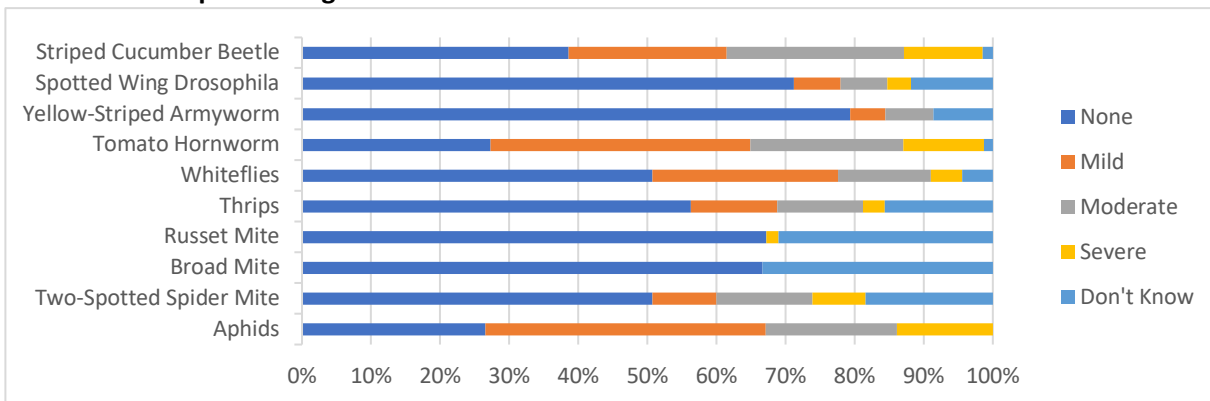
2019 responses to: "What crops do you grow during each season in your high tunnel?"			
Spring	Summer	Fall	Winter
Greens (54)	Tomato (71)	Greens (46)	Greens (44)
Tomato (41)	Cucurbits (55)	Tomato (39)	Herbs (10)
Transplants (38)	Pepper (53)	Herbs (29)	Alliums (4)
Cucurbits (27)	Herbs (32)	Pepper (26)	Carrots (4)
Herbs (23)	Eggplant (31)	Cucurbits (20)	Transplants (5)
Pepper (19)	Transplants (18)	Cut Flowers (17)	
	Cut Flower (18)	Transplants (14)	
	Ginger (14)	Eggplant (13)	
	Greens (10)		

While the patterns were very similar in both years, there were a couple of noteworthy changes: In 2019, eggplants (in summer) increased in popularity, as did cut flowers and ginger (in summer and fall). Greens (in summer) fell slightly. Growers mentioned continuing to produce transplants into the fall and winter, as well as in spring and summer.

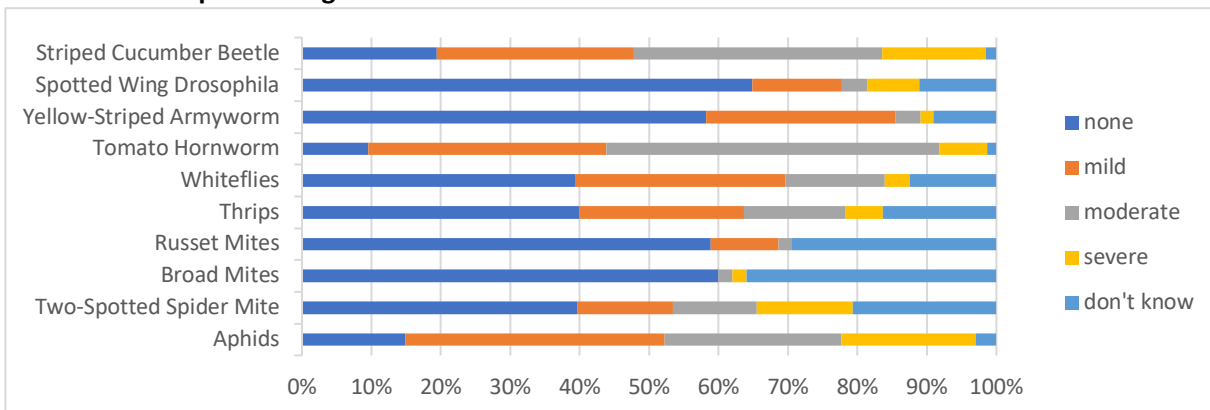
### 3. Pest and Disease Problems in High Tunnels.

Results were nearly identical in 2016 and 2019. Among pests, **aphids, striped cucumber beetle, and tomato hornworm** were most frequently cited as causing mild, moderate or severe problems. **Whiteflies** and **thrips** were the next most frequently cited as causing mild or moderate problems. Mites (two-spotted spider, broad, and russet) and thrips were most frequently mentioned as “don’t know”, suggesting that growers may not know how to identify these pests or the damage they cause.

#### Common insect pests in high tunnels - 2016

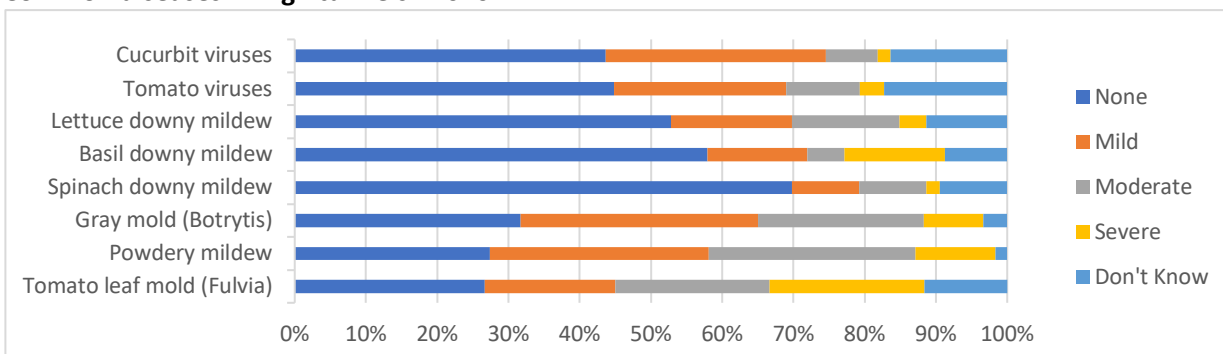


#### Common insect pests in high tunnels - 2019

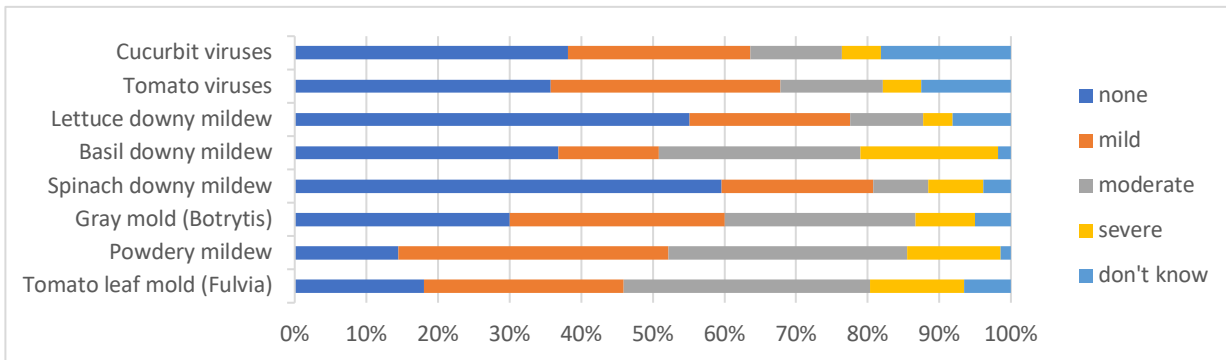


Among diseases, **tomato leaf mold, powdery mildew** and **gray mold** were most frequently cited as causing mild, moderate or severe problems. In 2019, **tomato leaf mold** and **powdery mildew** remained the most problematic. The proportion of growers citing moderate or severe problems caused by **basil downy mildew** increased in 2019.

#### Common diseases in high tunnels - 2016



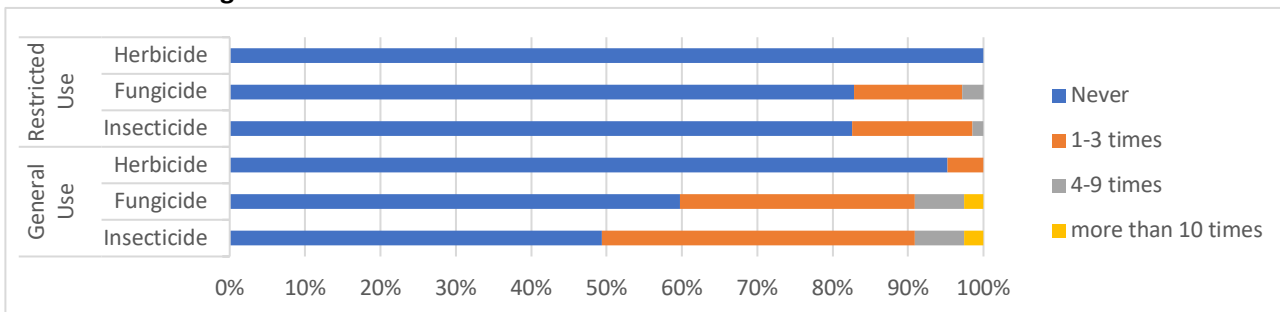
#### Common diseases in high tunnels - 2019



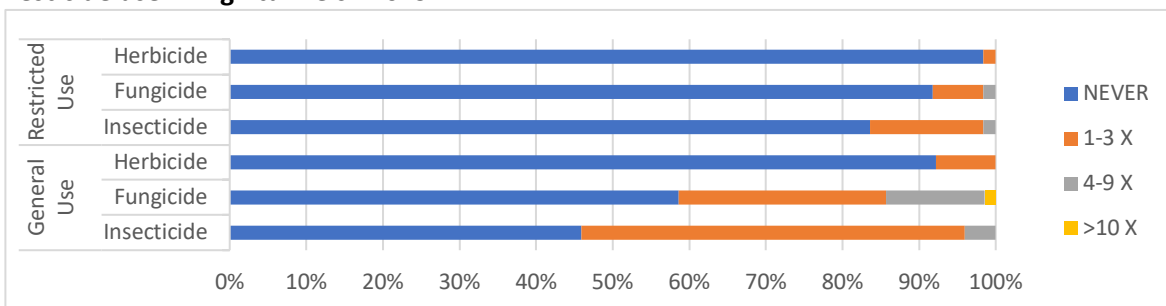
In 2016, voles were described as causing mild (35%), moderate (35%) or severe (15%) problems, with only 15% of respondents reporting that voles did not cause any problems. Similarly, in 2019, voles caused mild (39%), moderate (30%) or severe (7%) problems, with a slightly greater percentage of growers (22%) reporting that they caused no problems.

Most respondents (46-98%, depending on the category of material) did not use pesticides in their high tunnels in the year prior to the survey, in either year. Among those that used pesticides, most used general-use insecticides or fungicides 1-3 times during the year. Based on the numbers of respondents and number of applications reported, we estimated 117 and 101 applications of general use insecticides (GI) and fungicides (GF), respectively, and only 29 and 33 applications of restricted use insecticides (RI) and fungicides (RF), respectively, were made among all respondents in 2016. In 2019, we estimated 92 and 104 applications of GI and GF, respectively, and only 22 and 14 applications of RI and RF, respectively, were made among all respondents. Herbicides were very rarely used in high tunnels. While these correspond to reductions in use of most categories of pesticides over the past three years (-21%, +3%, -24%, -56% for GI, GF, RI, and RF respectively), conclusions should be made with caution, based on these small numbers of respondents and small numbers of applications. Our surveys confirm that growers use relatively few chemical pesticide inputs in their high tunnels.

**Pesticide use in high tunnels - 2016**



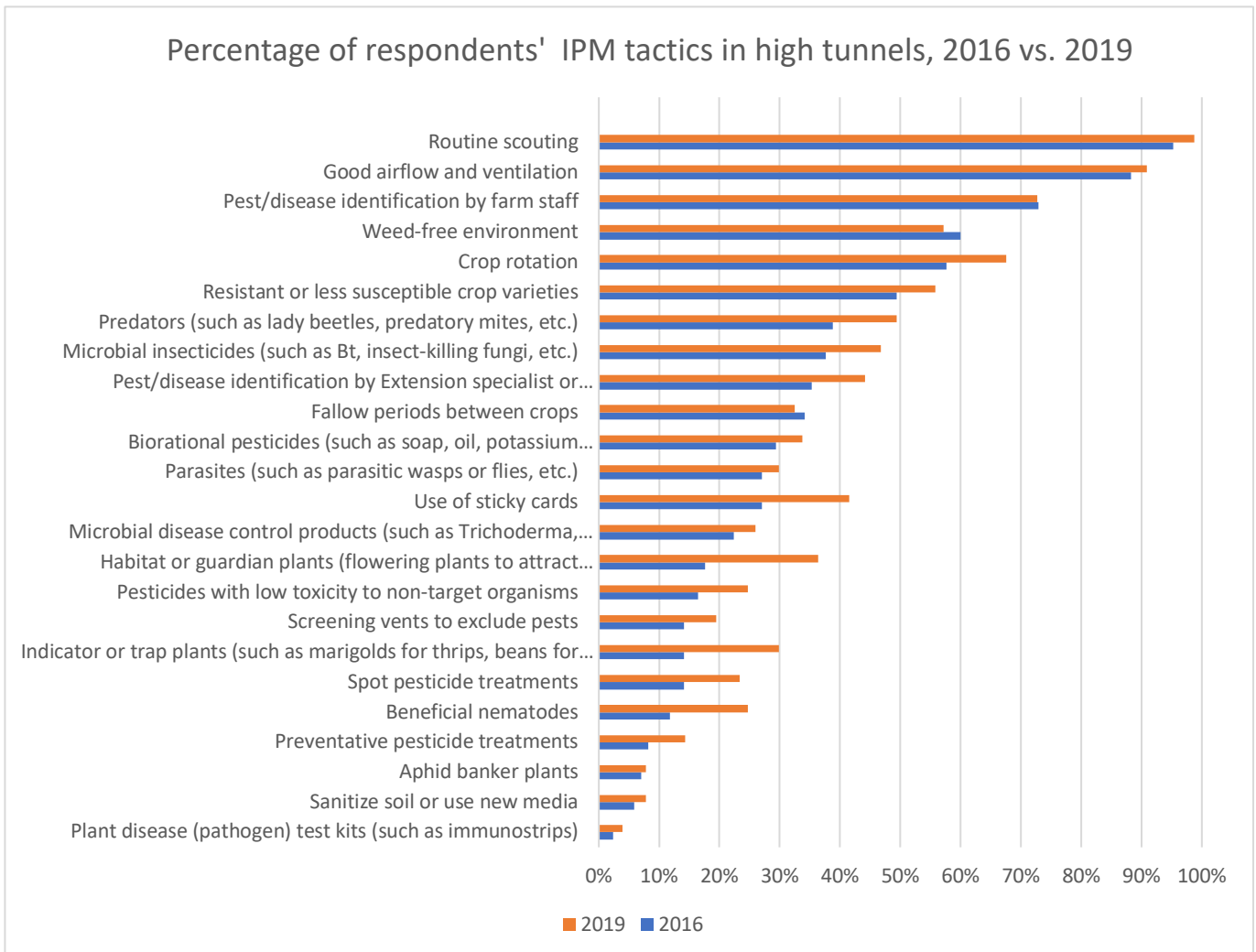
**Pesticide use in high tunnels - 2019**



### Insect and disease management practices used in high tunnels

Growers reported using a wide variety of IPM tactics in high tunnels in both years. Initially, plant-mediated systems such as banker plants, indicator or trap plants, and habitat plants were among the least frequently used. Nearly all growers reported using routine scouting and good airflow management to reduce pest and disease problems.

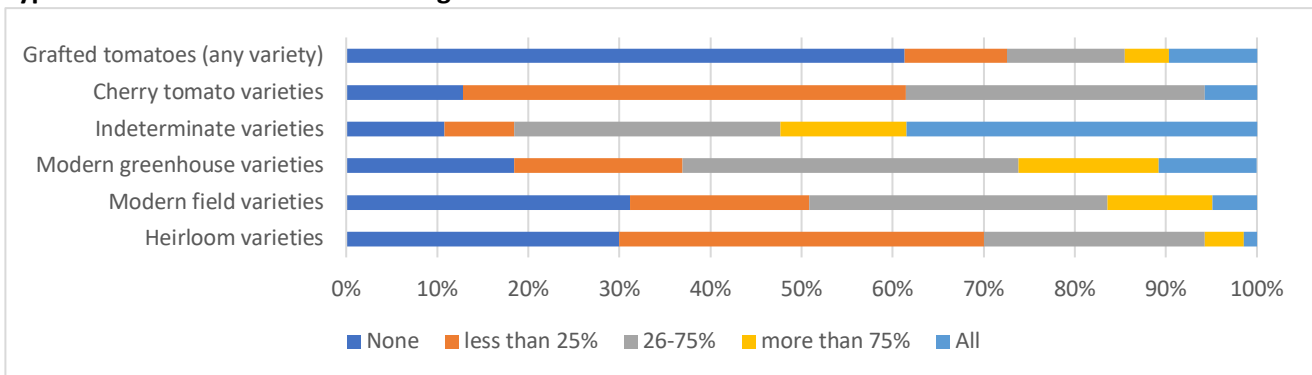
In 2019 (orange bars), we saw notable increases (>10%) in the percentages of growers using **crop rotation, predators, use of sticky cards, habitat or guardian plants, indicator or trap plants, and beneficial nematodes**. This was particularly encouraging, as our research & outreach efforts focused on the use of habitat plants, indicator/trap plants, predators, and sticky cards.



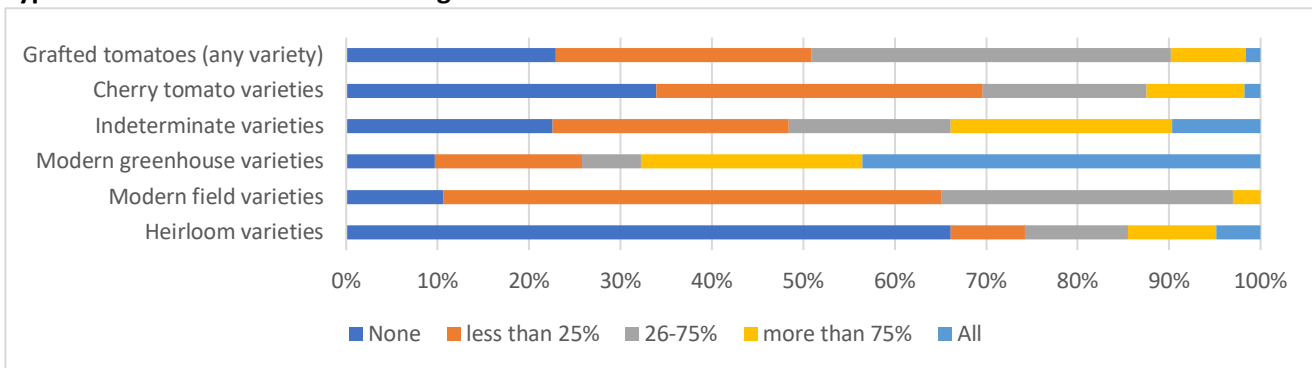
#### 4. High Tunnel Tomato Crop Quality & Yields

We observed large shifts in responses to questions about the types of tomato varieties grown in high tunnels. Between 2016 and 2019, the percentage of respondents that grow at least some **grafted tomatoes** doubled, from around 40% to nearly 80%. The percentage growing exclusively “**modern greenhouse varieties**” increased from around 10% to over 40%. The percentage growing at least some **cherry tomato varieties** fell from 86% to 66%; and the percentage growing at least some **heirloom varieties** fell from 70% to 35%.

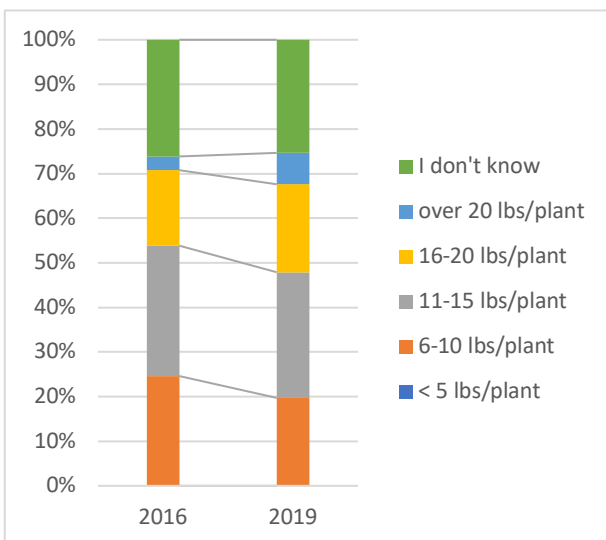
##### Types of tomato varieties used in high tunnels - 2016



##### Types of tomato varieties used in high tunnels - 2019



##### Reported high tunnel tomato yields



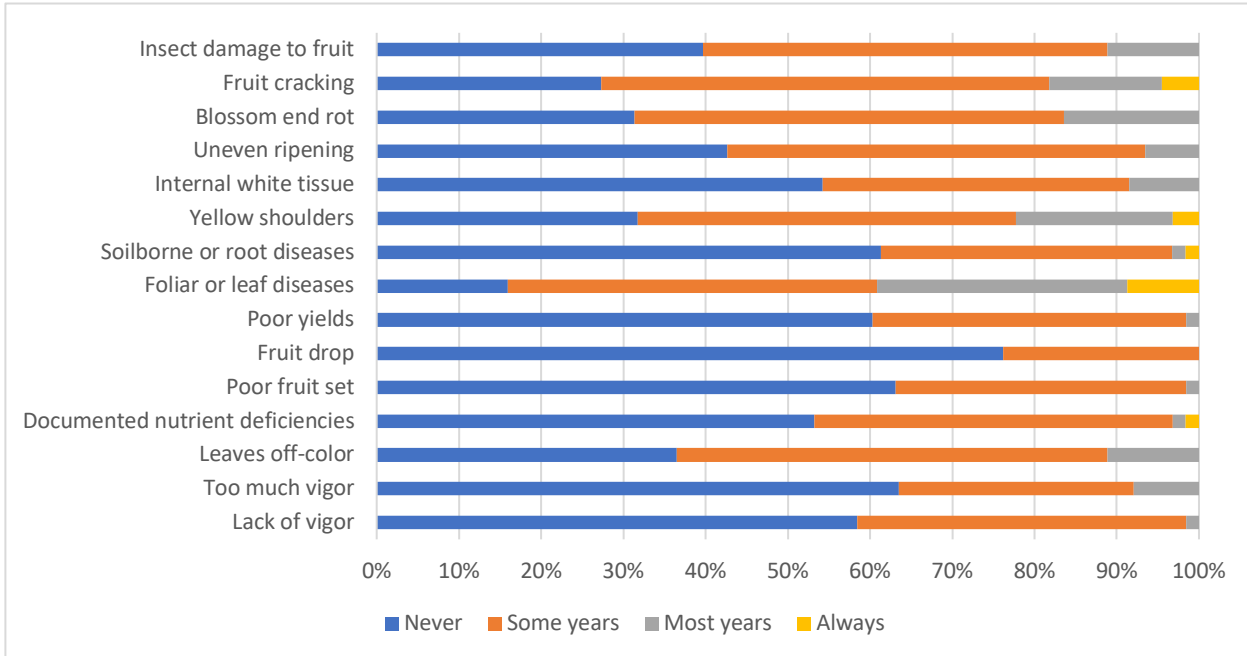
Respondents were asked to estimate average total high tunnel yield in pounds of marketable fruit per plant during the prior year. Using average values for each range, the mean yields increased from 9.5 (in 2016) to 10.4 lbs/plant (in 2019).

It is important to note that yield for cherry tomatoes would be different (and much less) than yields of indeterminate greenhouse tomatoes, for example; and shifts in variety selection could certainly explain the observed yield differences. Important notes: few growers reported yields exceeding 20 lbs/plant; and in both years, approximately 25% of respondents did not know their yields during the previous year.

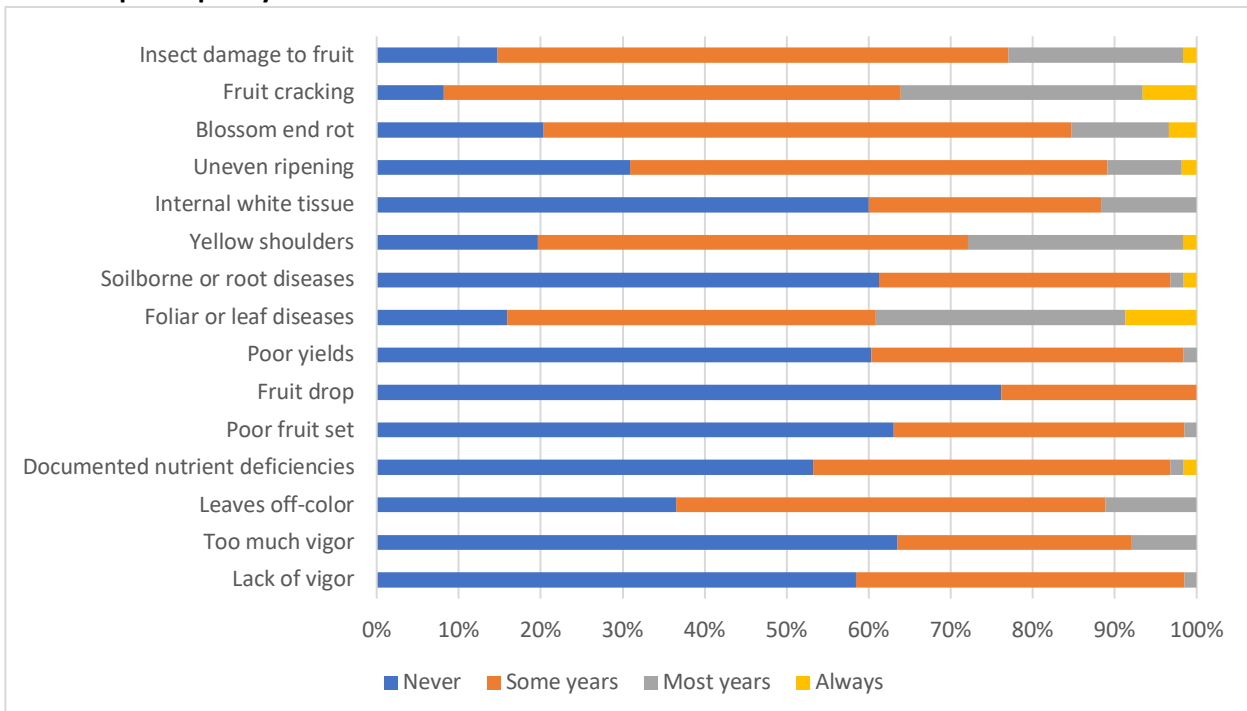


Reported issues with fruit and plant quality were very similar in both years. Over 60% of respondents observed foliar diseases, off-color leaves, fruit cracking, insect damage on fruit, blossom end rot, and yellow shoulder **in some, most, or all years** in their high tunnel tomatoes. Other production issues were less commonly observed, but over 60% of respondents felt that **all of these issues except** fruit drop, off-color leaves, and too much vigor resulted in a loss of marketable yields when they did occur.

**Fruit and plant quality issues - 2016**



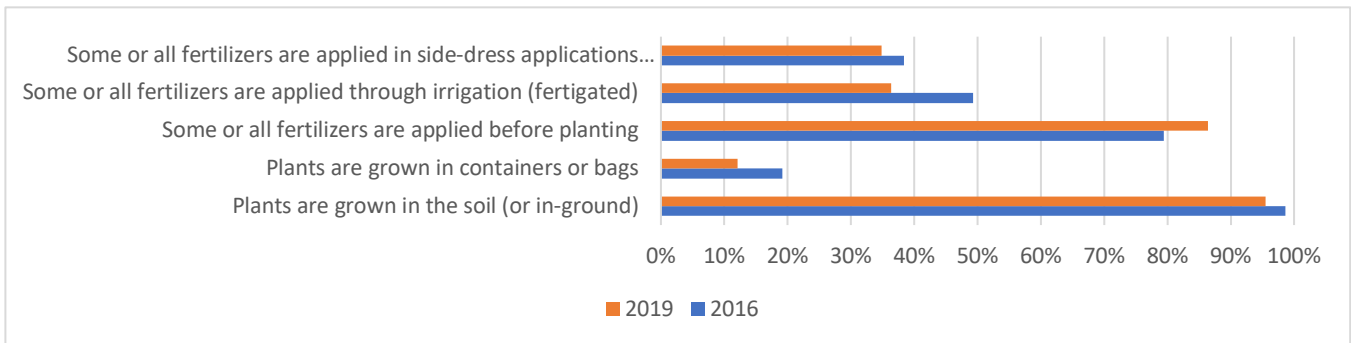
**Fruit and plant quality issues - 2019**



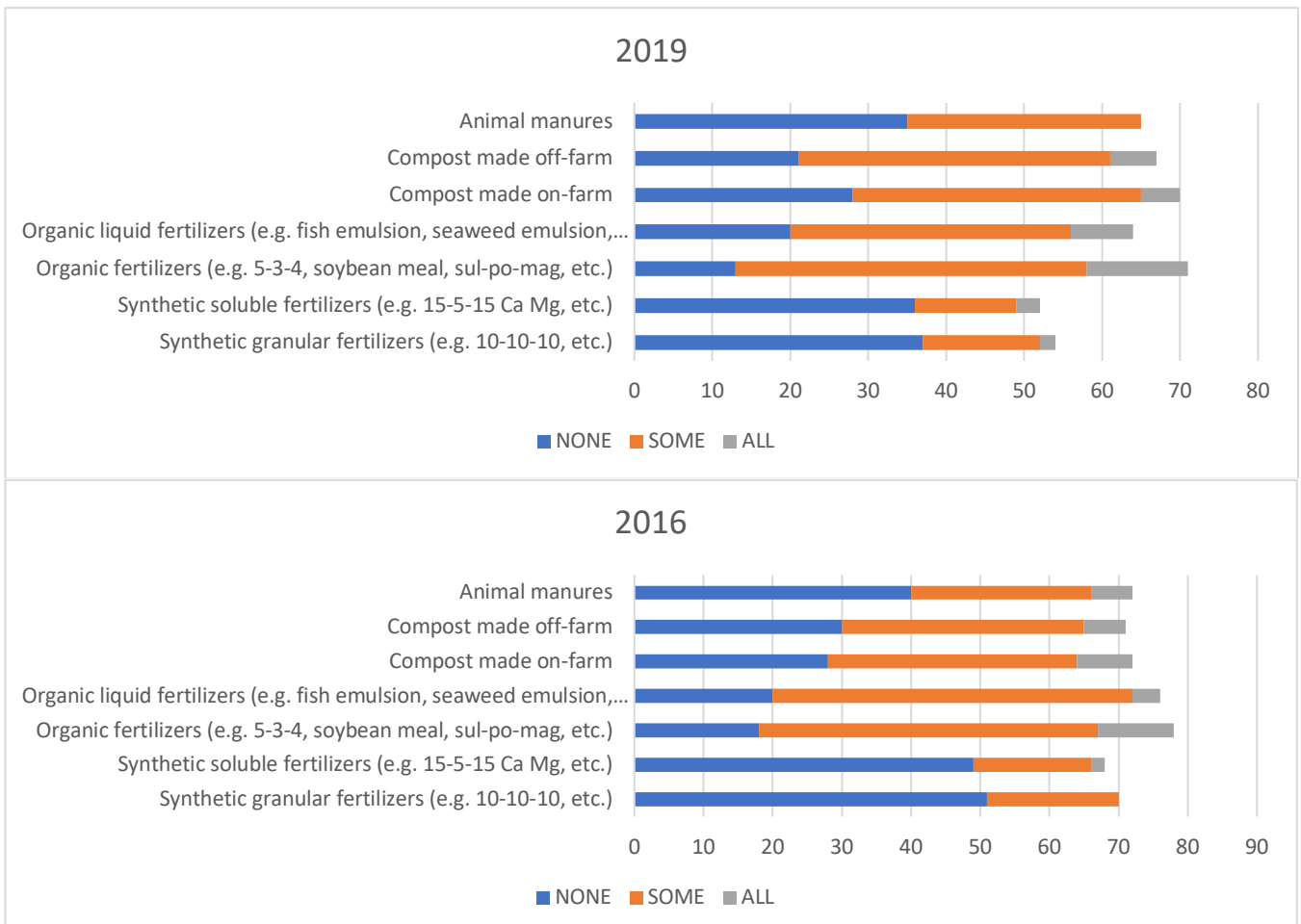
### 5. Fertilization, Nutrient and Irrigation Management

Nearly all respondents (reported that they were growing tomatoes in-ground. However, a small percentage (19% in 2019, 12% in 2016) reported that they were growing tomatoes in containers or bags, which suggests that some are growing both in soil and in media. The majority of growers apply some or all fertilizers pre-plant, and a smaller percentage (50% in 2016, 35% in 2019) of growers apply fertilizers through the irrigation/drip system (e.g. fertigate). Over 75% of respondents reported using organic solid and liquid fertilizers, whereas 25% reported that they used synthetic soluble or granular fertilizers. Most reported that they used a mixture of sources; with only a few growers using only a single source (14% used only organic solid fertilizers, 11% used only compost made on-farm, for example).

#### Fertilizer application strategy

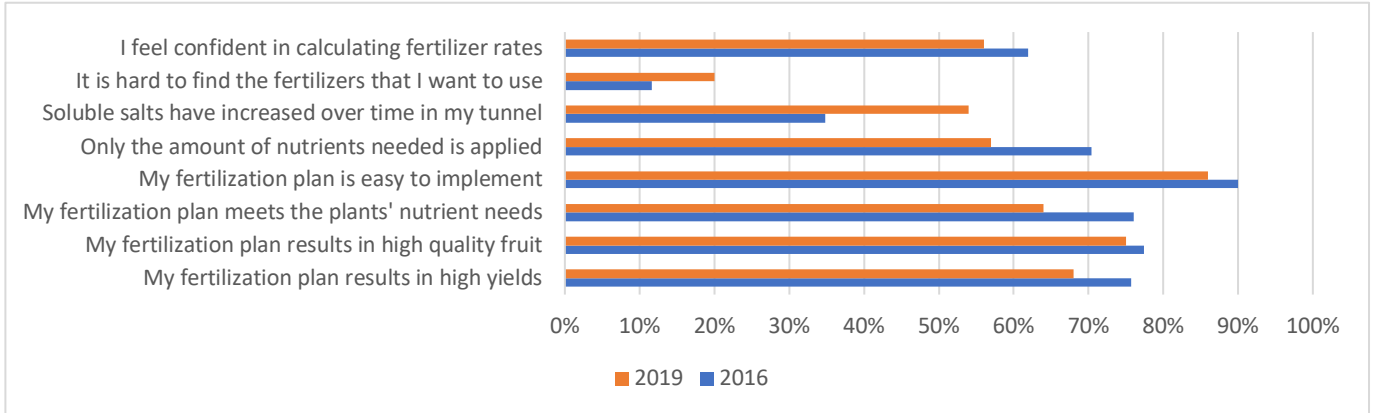


#### Fertilizers used

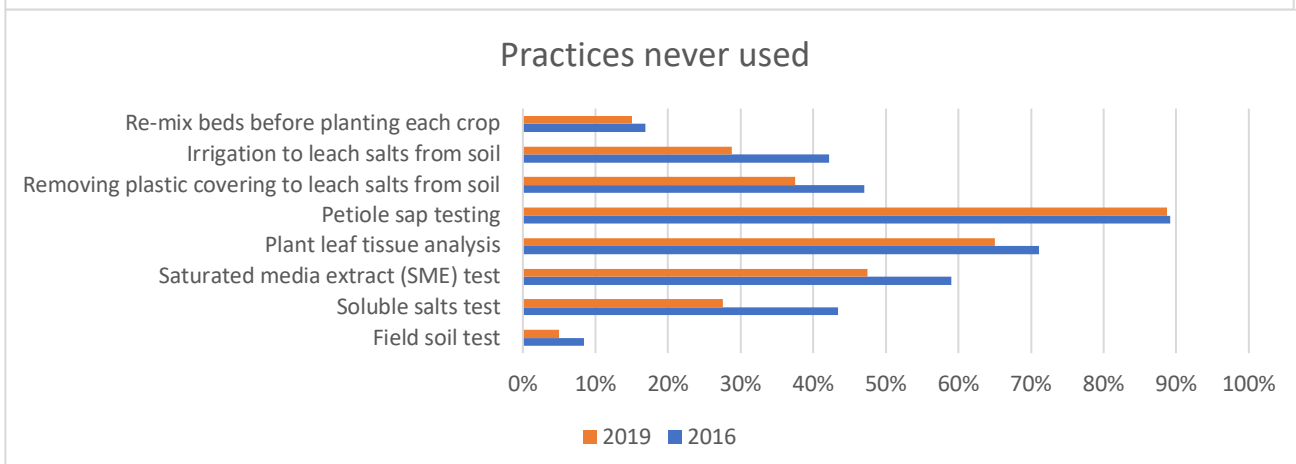
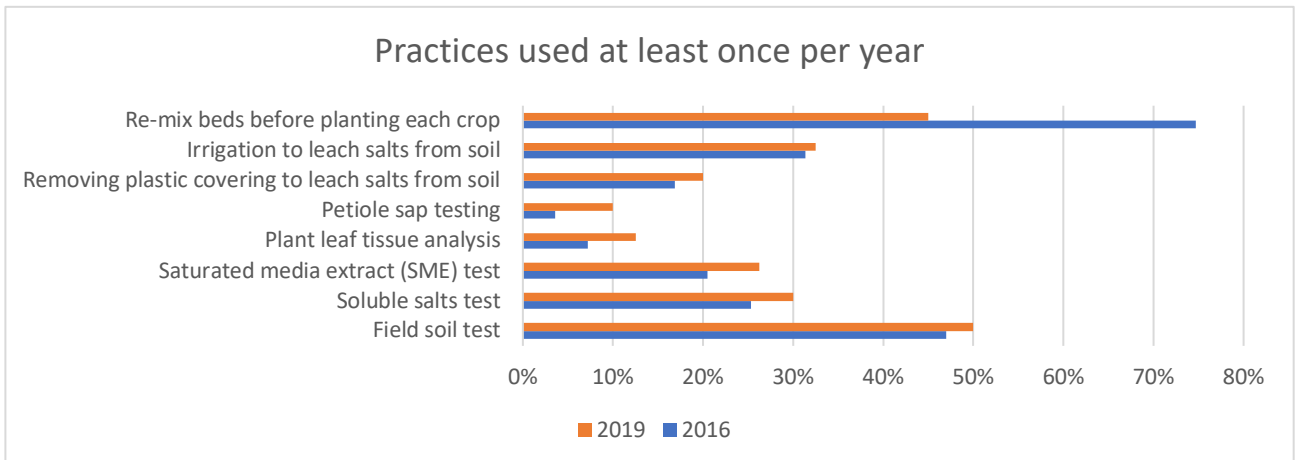


**Perceptions about nutrient management/fertilization**

In both years, the majority of growers were happy with their fertilization plan. In 2016, over 75% of respondents agreed somewhat or strongly with the statements that their fertilization plan resulted in high yields, high quality fruit, met plant nutrient needs, and was easy to do. **In 2019, these numbers fell slightly, but remained over 60%.** Over 60% (2016) or 50% (2019) of respondents felt confident in calculating fertilizer rates, and felt that they were applying only the amount of nutrients needed. **Between 2016 and 2019, we observed increases in the percentage of growers who felt it was hard to find the fertilizers they wanted and who felt that soluble salts increased over time.**



**Nutrient management practices used in high tunnels**

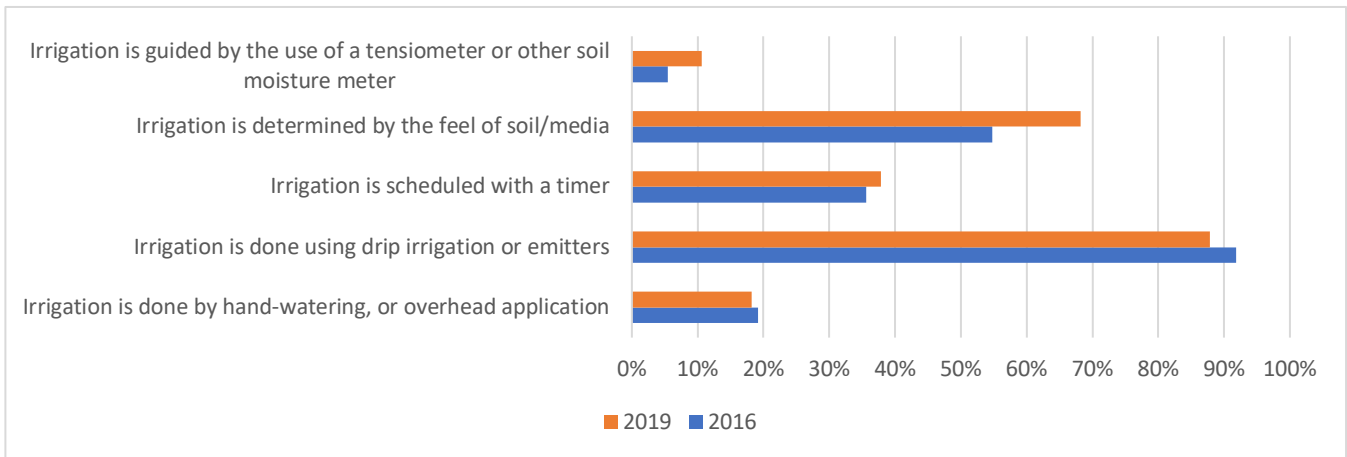


In both years, soil testing was much more commonly used than plant tissue or petiole sap testing. Most growers reporting using field soil tests, with fewer growers using soluble salts tests and fewer still using the SME.

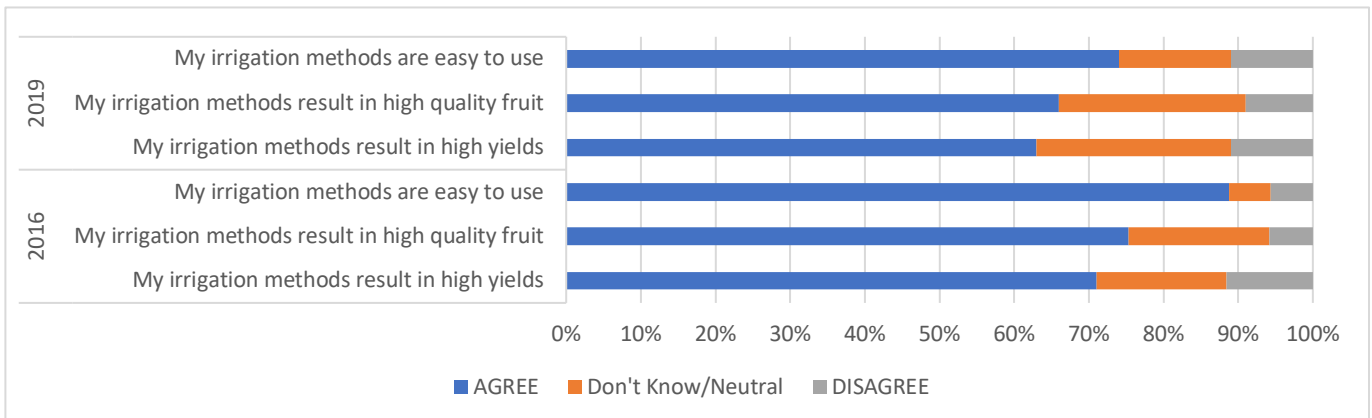
**Slightly higher percentages (3-6%, on average) of growers reported soil testing, soluble salts testing, plant leaf tissue analysis, and other nutrient management techniques in 2019 compared with 2016.** We also observed a measurable drop (nearly 10% in most cases) in the percentage of growers who *never* leached soluble salts (by removing plastic or by irrigating), tested for soluble salts, or used SME tests. Surprisingly, in 2016, over 75% of growers reported that they re-mix beds at least once per year; but this dropped to 45% in 2019.

**Irrigation practices used in high tunnels**

Most respondents (around 90%) use drip irrigation. Around 35% of the respondents use a timer to schedule their irrigation, and this was the same in both years. **We observed slight increases in percentage of respondents who use a tensiometer to schedule irrigation events (5% in 2016; 11% in 2019); and who use feel of soil/media to determine when to irrigate (55% in 2016, 68% in 2019).**



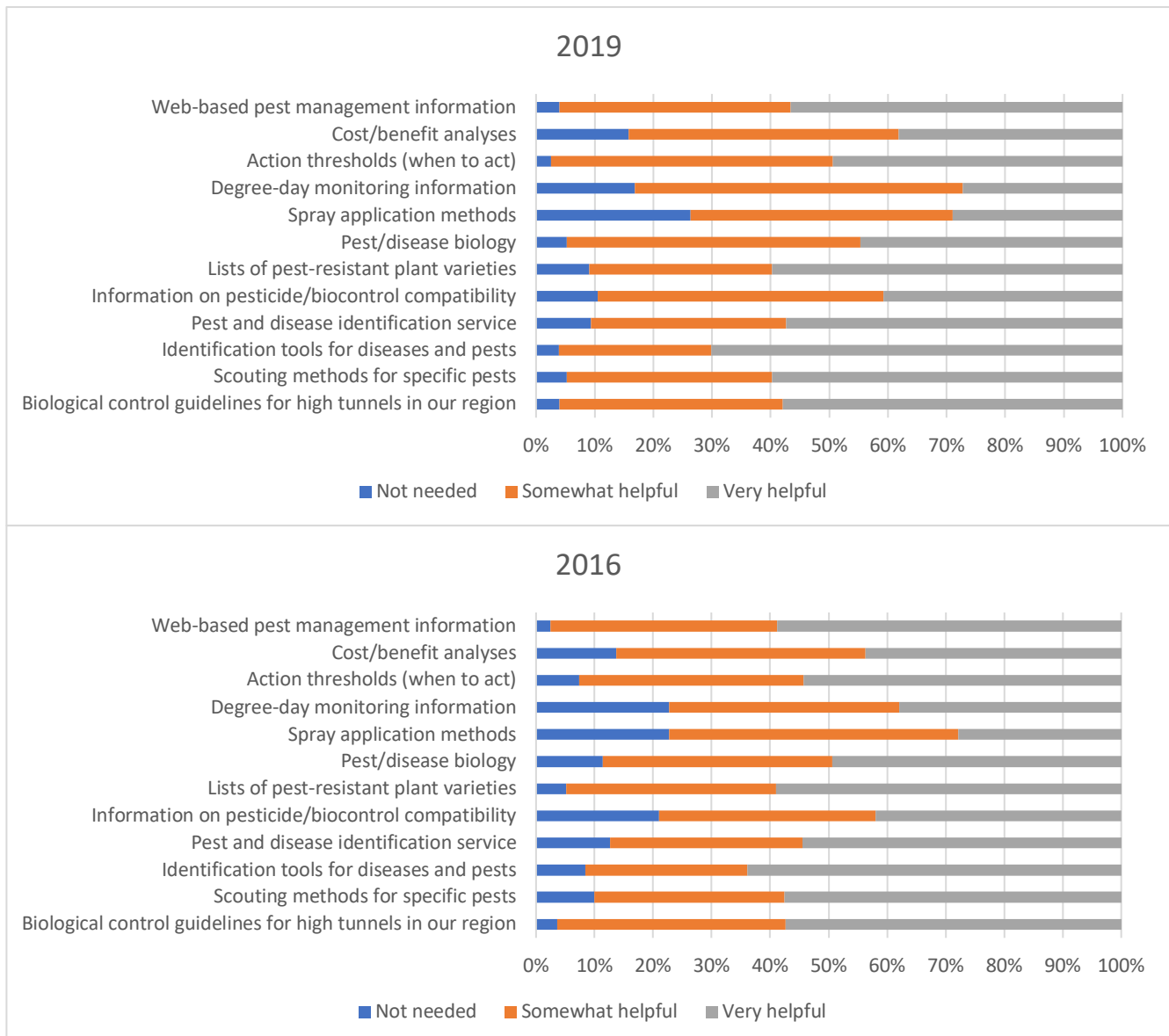
Nearly all respondents felt their irrigation methods were easy to use, **but 25-29% (in 2016) and 34-37% (in 2019) of respondents said that they disagreed with or did not know whether their irrigation strategy resulted in high yields or high quality fruit.**



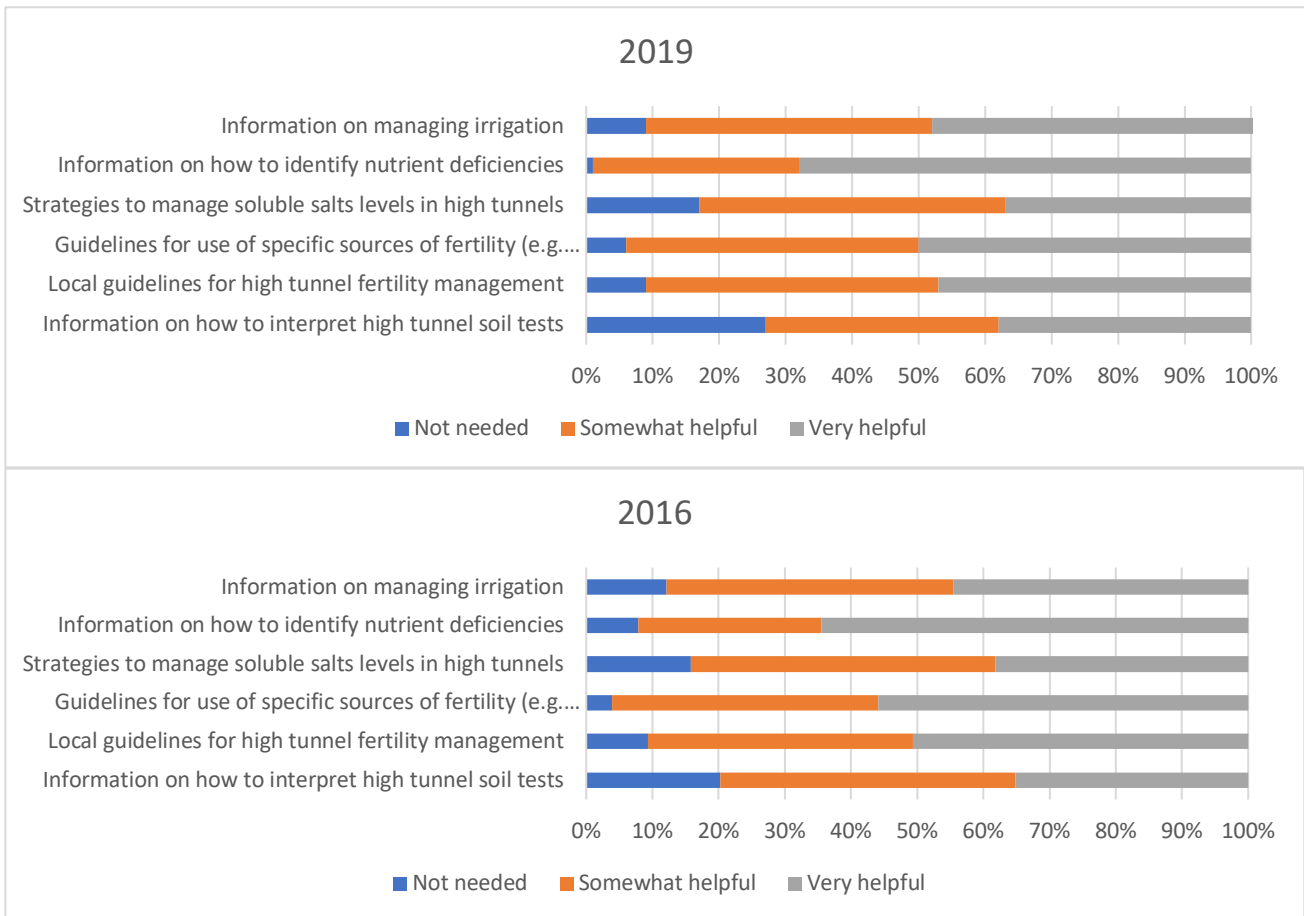
### 6. Resources/Information Needed

We asked participants specifically how they would like to receive information that would help them manage pests, diseases and crop and soil fertility. The most popular responses to this question were **written fact sheets (accessible online, 81% in 2016 and 92% in 2019), workshops and conferences (77% in 2016 and 65% in 2019), twilight meetings (58% in 2016 and 51% in 2019), and short (5-10 minute) instructional videos or “webinettes” (57% in 2016 and 72% in 2019).** 39% (2016) and 29% (2019) were interested in full-length (30m-1hr) webinars, and others wrote in suggestions, including: online video library, written fact sheets, farm visits by extension specialists, website with easily accessed info, efficacy charts for biorationals, and good online photos with decision trees for diagnosing issues.

When asked what resources or information would help them manage insect and disease pests in high tunnels, respondents were most interested in **identification tools for diseases and pests, regional biocontrol guidelines for high tunnels, web-based pest management information, lists of pest-resistant plant varieties, and action thresholds for specific pests/diseases.** Results were very consistent between years.



When asked what resources or information would help them manage crop fertility in high tunnels, respondents were most interested in **information on how to identify nutrient deficiencies, guidelines for use of specific sources of fertility (e.g. composts), and local guidelines for high tunnel fertility management**. Again, results were very consistent between years.



Growers also provided a detailed list of suggestions for topics for the biennial High Tunnel Tomato Conference, which will next take place in fall/winter 2020.