The OREI Cucurbit Crops Project Year 1 Whole Team and Advisory Panel/Cooperative Grower Surveys

TECHNICAL REPORT

Nieyan Cheng, Ph.D. Student, Department of Economics and Center for Agricultural and Rural Development (CARD), Iowa State University, nycheng@iastate.edu

Wendong Zhang, Assistant Professor, Department of Economics and Center for Agricultural and Rural Development (CARD), Iowa State University, wdzhang@iastate.edu

February 2021

Resilient Systems for Sustainable Management of Cucurbit Crops, 2019 Project Narrative. Dr. Mark Gleason, Project Director. Award number 2019-51300-30248. USDA Organic Agriculture Research & Extension Initiative (OREI). Iowa State University, University of Kentucky, and Cornell University.

Table of Contents

1 Main Findings

1.1 The Whole Team Survey

- This survey conducted from July to September 2020 is based on responses of 17 project team members located in Iowa, Kentucky, and New York.
- When making the decision to adopt a mesotunnel management system, respondents cared most about economic factors related to profit, yield, and cost structure, and non-economic factors such as plant growth, pollination, and the impact of insecticide/fungicide use.
- When making the decision to adopt biological control approaches, respondents showed more diversity in choices, but focused more on non-economic factors.
- Most respondents focused on mesotunnel: (*a*) profitability; (*b*) cost-effectiveness; and (*c*) scalability.

1.2 The Year 1 Grower Survey

- This Year 1 Grower survey is based on 13 responses of Iowa, Kentucky or New York on-farm cooperators (growers) or university-field plot managers from July to November 2020. All cooperator grower respondents are experienced farmers, and most are familiar with cucurbit planting.
- Growers planted more acreage to cucurbit crops in 2020 compared to 2019.
- During cucurbit planting, growers applied different types of permeable row covers, pollination methods, weed management methods, rotation crops, and pest management systems.
- Respondents were receptive to possible advantages of mesotunnel and biological control approaches on cucurbit production; however, they also hoped for more options for crop disease management.
- When making decisions to use a pest management system, growers consider improving yields, product quality, and soil quality, as well as reducing pesticide runoff or leaching, as the most important factors.
- Seventy-five percent of respondents were concerned about the effectiveness of biological control products, increased heat stress on crops, high winds, and increased insect and weed pressure.

2 Organic Cucurbit Mesotunnel Production Technologies

The cucurbit family has over 900 species, including cucumber, squash, melon, pumpkins, and gourds. Pumpkins and squash are significant income sources for specialty crop growers in the United States. According to the United States Department of Agriculture (USDA) 2020 National Retail Special Crop report (USDA 2020)[1], pumpkin and squash account for 18% of the top 10 vegetables marketed in the United States.

Consumer demand for fresh, locally grown organic produce, including cucurbits, is rising. However, cucurbit growers in the eastern United States struggle to capitalize on this opportunity because of severe damage caused by pests and diseases, which collectively cost growers more than $100 million per year.[2] The most critical threats include cucumber beetles, squash bugs, squash vine borer, bacterial wilt, cucurbit yellow vine disease, and powdery and downy mildews. The organic options for these pathogens are quite limited, and organic pesticides often fail to stop these insects and diseases and may harm pollinators. Alternative management options for cucurbit pests and diseases—perimeter trap crops, late planting, crop rotation, biochemical lures, and plant resistance activators—often fail to provide adequate control.

Organic cucurbit growers lose income not only from pest and disease damage but also from missing key marketing opportunities, as inconsistent yield and quality threaten producer-to-consumer distribution. Mesotunnels (see figure 7) are structures deployed above the crop using a tough, breathable, light-permeable, nylon-mesh fabric covering over three-to-five-foot support hoops. The fabric acts as a season-long barrier to keep out cucumber beetles, squash bugs, and squash vine borers and limits the diseases they spread. Mesotunnels also protect against weather extremes (e.g., heavy rain, hail, high wind) while increasing profitable early-season harvests. Thus, mesotunnels provide a promising solution for managing major pests and pathogens of cucurbits and are highly amenable to integrating biologicals for further pathogen control.

In this three-year USDA organic agriculture project, the University of Kentucky, Iowa State University, and Cornell University and cucurbit growers from three distinct geographic growing regions (New York, Iowa, and Kentucky) are collaborating in experimental field trials to scale up mesotunnel production systems. The goal is to develop commercial-scale systems utilizing mesotunnel and other biological strategies to control major cucurbit insects and diseases.

In year 1 of the project (2020), project members, including graduate students, research technicians, co-PIs, and on-farm cooperators, conducted field trials with mesotunnels using various technologies at each location. At the end of year 1, researchers assessed the efficacy of the mesotunnels approach. This report summarizes: (*a*) growers' experiences in 2020 using

---

[1] USDA National Retail Report Specialty Crops Vol XIV-No 42 October 16, 2020

[2] Resilient Systems for Sustainable Management of Cucurbit Crops, 2019 Project Narrative. Dr. Mark Gleason, Project Director. Award number 2019-51300-30248. USDA Organic Agriculture Research & Extension Initiative (OREI). Iowa State University, University of Kentucky, and Cornell University.

mesotunnel technology with cucurbit crops; and, (*b*) the research team and advisory panel members' impressions on the project's approach to using mesotunnels and bio-control for more sustainable cucurbit crops production.

3 Methodology

In June and July 2020, we designed two online Qualtrics surveys to obtain information on the economic and non-economic factors influencing growers when they make decisions on mesotunnel and bio-control approach adoption and to gather baseline year 1 farming information.

We sent an email with corresponding URL to the first survey, the "Whole Team Survey" (WTS), to graduate students, project investigators, research technicians, and advisory panel members. The WTS asked about economic and non-economic factors associated with growers' decisions to use mesotunnels and bio-control approaches and collected information about respondents' expectations of the project. When asked what questions respondents wanted the project to answer, most focused on mesotunnel: (*a*) profitability; (*b*) cost-effectiveness; and, (*c*) scalability. Between June 29 and September 8, 2020, we received 17 responses to the WTS survey.

Similarly, we sent an email to the second survey, the "Year 1 Cooperator Grower Survey" (CGS1), to the on-farm trial cooperators (growers) and university-field trial managers. The CGS1 includes information on demographics, cucurbit crops management, insect, pest, and disease control, and growers' year 1 experiences utilizing mesotunnels for cucurbit crops production on their farms. Between July 2 and November 11, 2020, we received 13 responses to the CGS1 survey.

The Iowa State University IRB granted the research protocol exempt status, as they assessed it was low-risk to respondents. For the purposes of anonymity, we removed respondents' names when summarizing and analyzing responses.

4 The Whole Team Survey

4.1 Basic Information

We received a total of 17 respondents to the WTS survey. As figure 1 shows, most respondents are technical/support staff, graduate students, and co-PIs in the cucurbit mesotunnel project. The remainder are mostly on-farm research managers with multiple project roles.

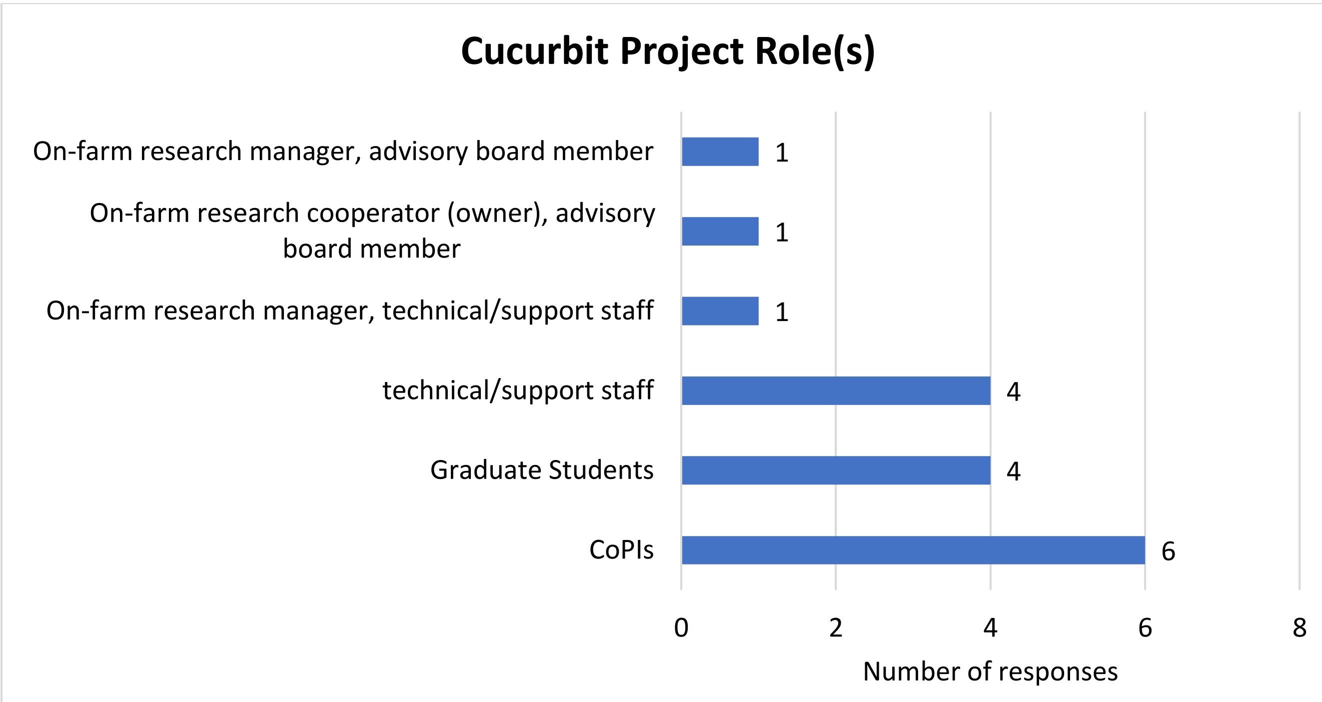


Figure 1. Respondents to the Whole Team Survey

Of the 17 respondents, 15 are distributed almost equally among Iowa, Kentucky, and New York. One respondent works in all three states as co-PI. Figure 2 shows respondent distribution by state.

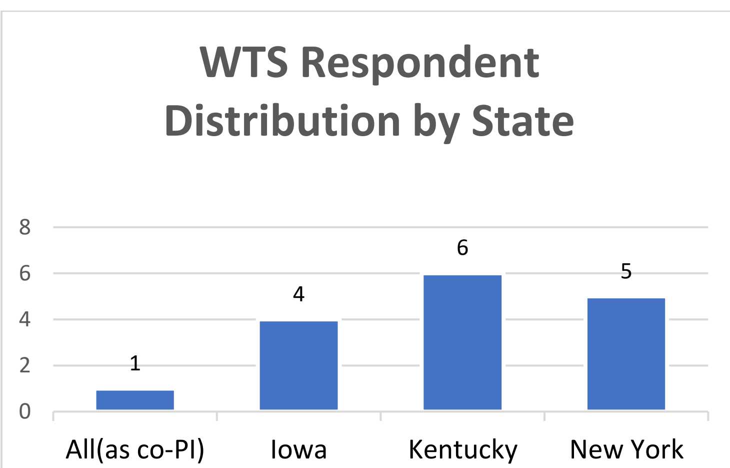


Figure 2. Respondent distribution by State.

4.2 Factors Influencing Cucurbit Growers' Management Decisions for the Adoption of a Mesotunnel Management System

We asked WTS survey respondents to rate a total of 17 factors that could potentially influence cucurbit grower's decision to adopt mesotunnels. Figure 3 shows the six factors that more than half of respondents rated as very important when making the decision to adopt a mesotunnel management system. Most respondents state that factors related to profit, yield, and cost structure are very important. Among the six factors, profitability was the most common answer, followed by capacity to reduce pest pressure, labor involved, and infrastructure cost.

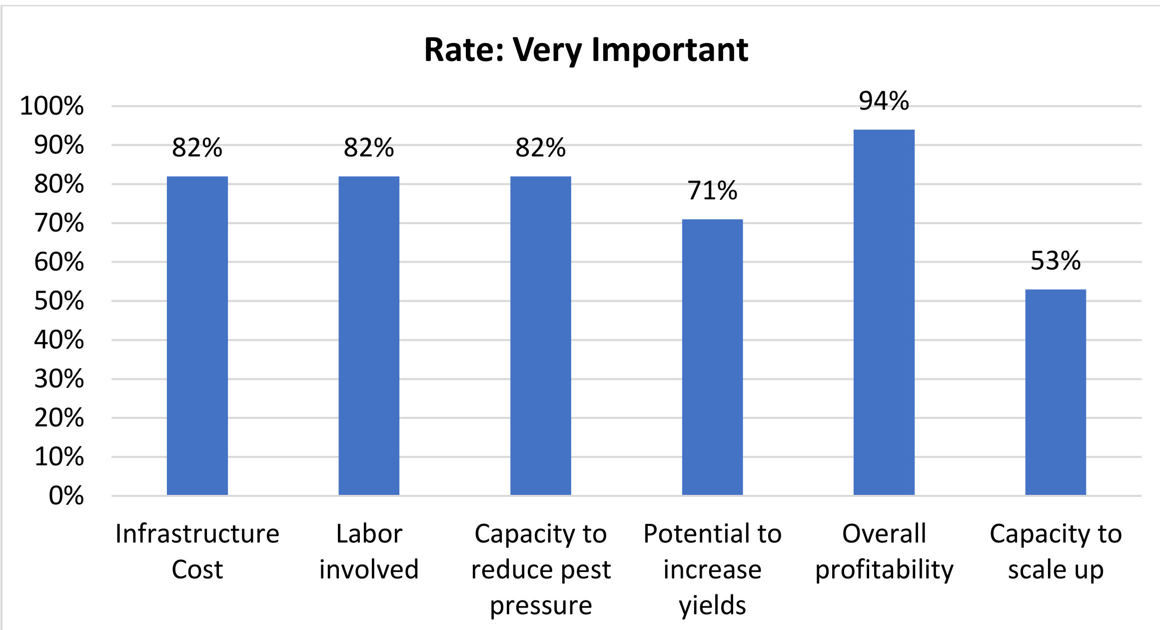


Figure 3. Factors respondents said are very important to cucurbit growers' decisions to adopt a mesotunnel management system.

Figure 4 shows the three factors influencing mesotunnel adoption that at least 50% of respondents rated as important. Most respondents state that impact on plant growth, efficient pollination, and the capacity to reduce insecticide/fungicide use are important factors. Of the three responses, efficient pollination was the most common answer, and impact on plant growth and capacity to reduce insecticide/fungicide use were equally common.

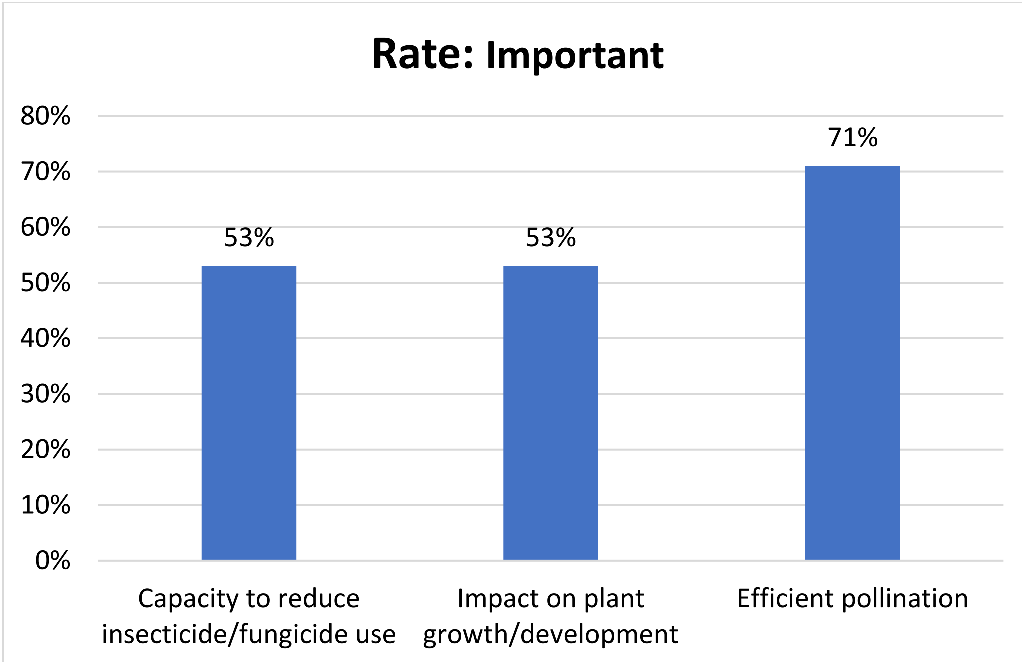


Figure 4. Factors respondents said are important in cucurbit growers' decisions to adopt a mesotunnel management system.

Other factors respondents said influence mesotunnel adoption include day-to-day net management, management of current spraying regime, weed management inside the mesotunnel, potential to increase product size, impact on temperature inside the mesotunnel, equipment needs to apply insecticides/fungicides, influence of peers, and recommendations of crop advisors. These factors havd almost equal numbers of respondents who deemed them important and respondents who deemed them unimportant.

4.3 Factors Influencing Cucurbit Growers' Decisions to Adopt Bio-control Pest Management Approaches

Figure 5 shows the three factors that more than 50% of respondents rated as very important to cucurbit growers' decisions to adopt biocontrol pest management approaches. Most respondents said factors related to ease of biocontrol application, the efficacy of bio-controls to suppress pests at a "reasonable" threshold, and potential to increase yield were very important.

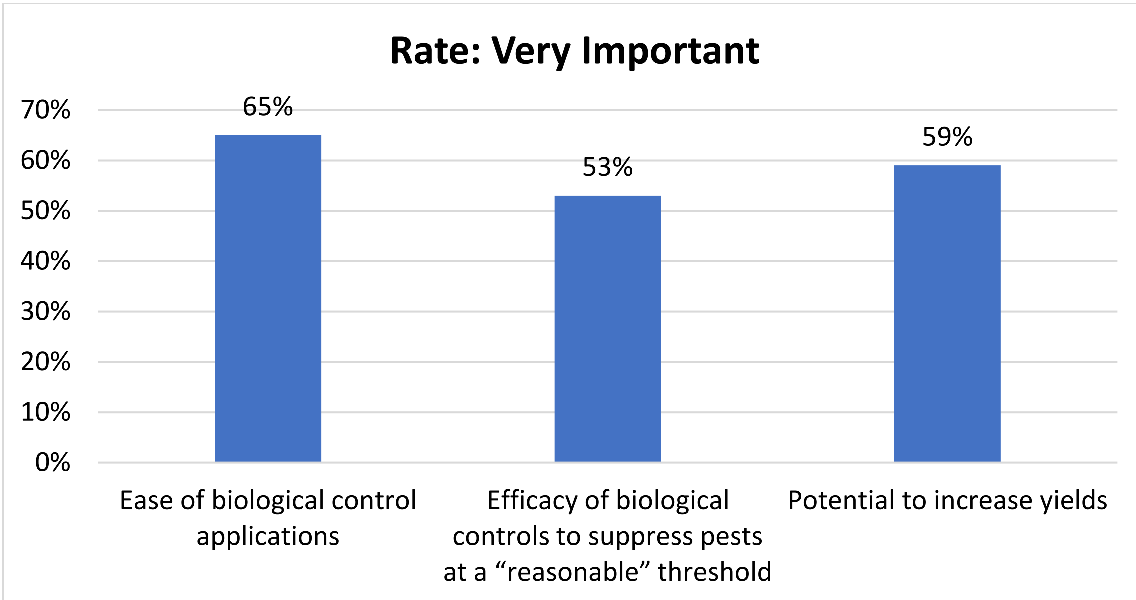


Figure 5. Factors respondents said are very important in cucurbit growers' decisions to adopt bio-control pest management approaches.

Figure 6 shows the three factors that more than 50% of respondents said are important to cucurbit growers' decisions to adopt bio-control pest management approaches. Most respondents said that reducing insecticide/fungicide use, the potential to improve product quality, and concern about current spray program integration are important factors.

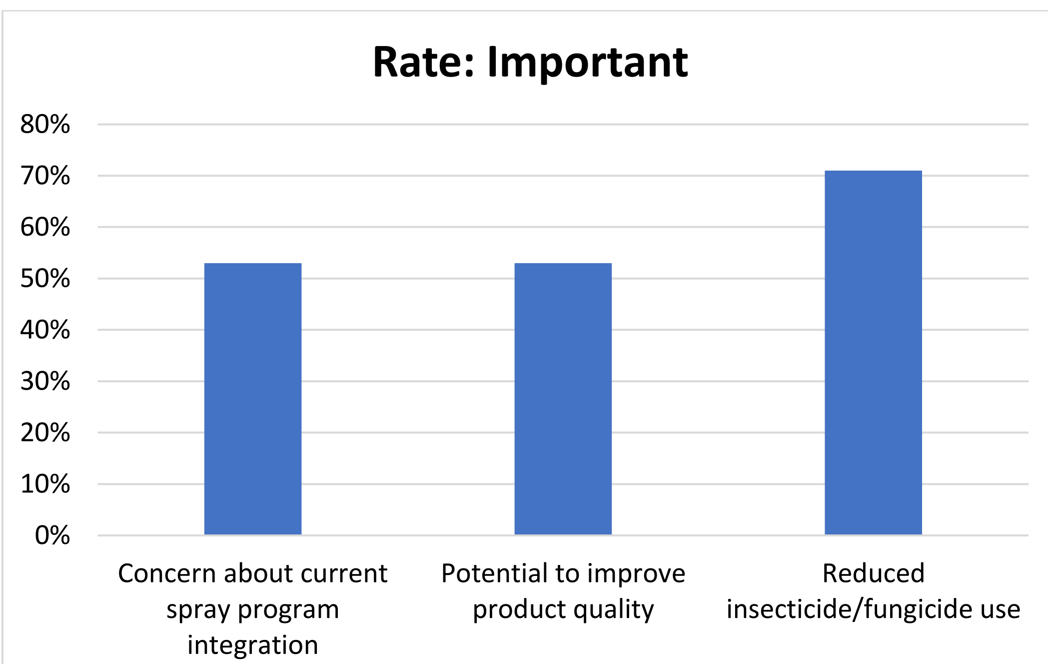


Figure 6. Factors respondents said are important to cucurbit growers' decisions to adopt biocontrol pest management approaches.

Other factors respondents say are important to biocontrol pest management adoption include time needed to gain sufficient knowledge for using biological controls, complexity of knowledge needed to use effectively, type of application equipment needed, grower values/beliefs about implementation of bio-control pest management, grower values/beliefs about safety of bio-control agents/products, concern about customer beliefs/values on biological control management, concern about effects on pollinators, influence of peers to adopt/not adopt, recommendations of crop advisors to adopt/not adopt, and cost of microbiological inputs. Respondents noted these factors are of almost equal importance.

Respondents' answers about bio-control approaches differed slightly from answers about the factors associated with mesotunnel production systems, as the answers about bio-control approaches have more variability, which indicates that respondents have more focal points for biocontrol approaches than mesotunnel production systems.

Figure 7. Mesotunnel installation. (Photo credit Jose Gonzalez, Iowa)

Figure 8. Mesotunnel with netting and sandbags to secure the netting. (Photo credit Kellie Damann, New York)

4.4 Respondents' Project Expectations

The survey asked respondents for their individual-level and general-level expectations from the project.

Individually, respondents were hoping to gain good feedback on mesotunnels from growers, learn more about organic production systems such as mesotunnels, biocontrol, and cover crops and understand their feasibility, and get experience with teamwork and conducting research projects.

Generally, respondents expected mesotunnels to be a new and practical system for producing cucurbits with minimal disease and pests and a cost-effective, efficient way to scale up organic cucurbit production. Moreover, respondents wanted to optimize the use of mesotunnels by maximizing yield and profit while reducing inputs, and they wanted to see a positive impact in other parts of the world where cucurbit growers face similar challenges.

5 Year 1 Grower Baseline Survey

5.1 General Information

We received 13 responses to the CGS1 survey. Respondents worked on the project as on-farm cooperator growers and university field trial managers. Figure 9 shows that the respondents were almost equally distributed among Iowa, Kentucky, and New York.

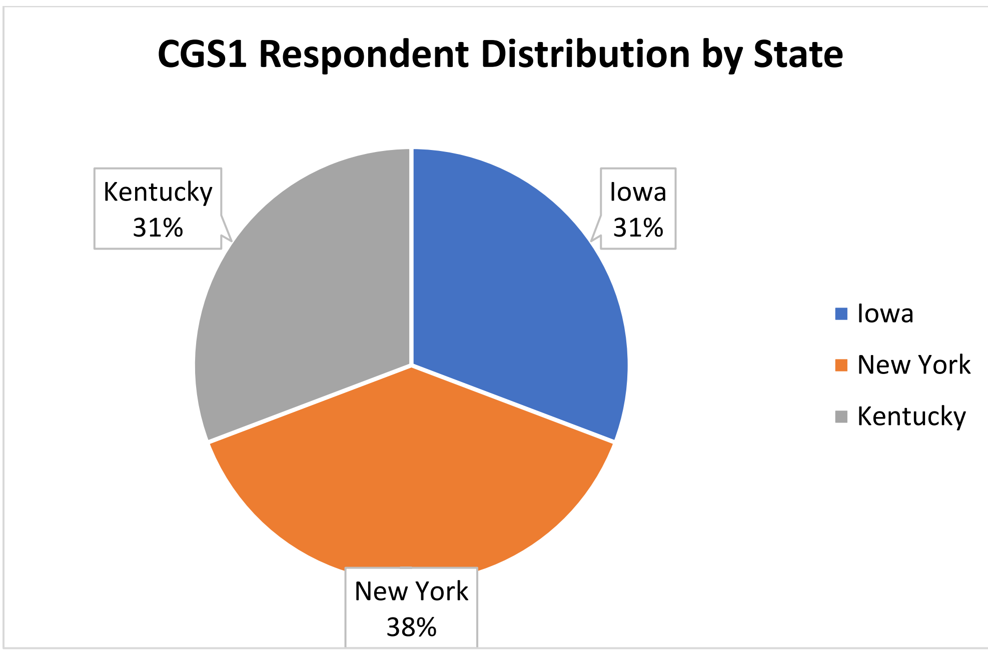


Figure 9. Distribution of respondents by state.

As figure 10 shows, the total acreage distribution of farms among respondents was quite diverse; however, most respondents (11 out of 13) had a farm less than 100 acres. Compared to 2019, more growers in 2020 chose to plant a larger percentage of their farms to cucurbit crops, especially the 10%-20% range. In 2019, 60% of respondents planted less than 10% of their farm to cucurbit, and only 20% planted 10% to 20% of their farm to cucurbits. However, in 2020 only 40% of the respondents planted less than 10% of their farm to cucurbits, and 40% of the respondents planted 10% to 20% of their farm to cucurbits (see figure 11). In both years, 20% of respondents planted 20%-30% of their farm to cucurbits.

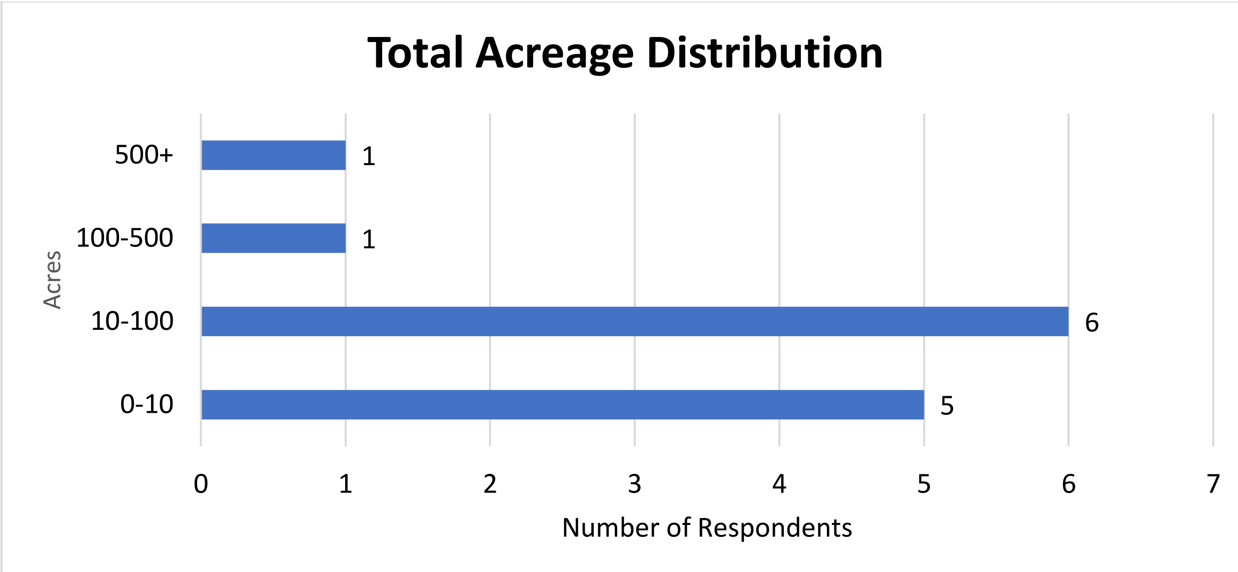
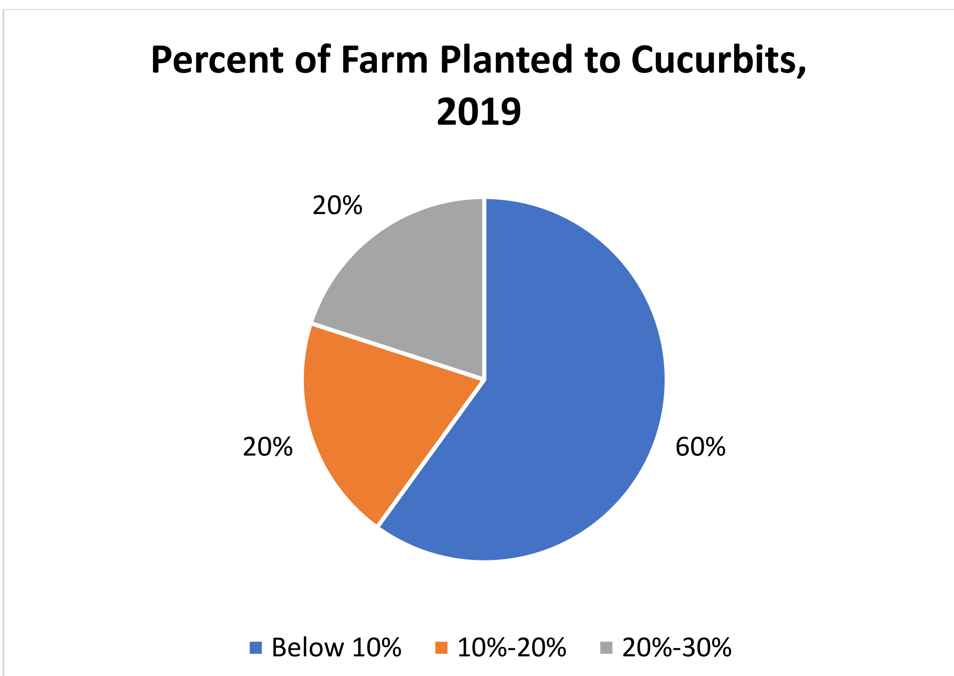


Figure 10. Total acreage distribution for respondents' farms.



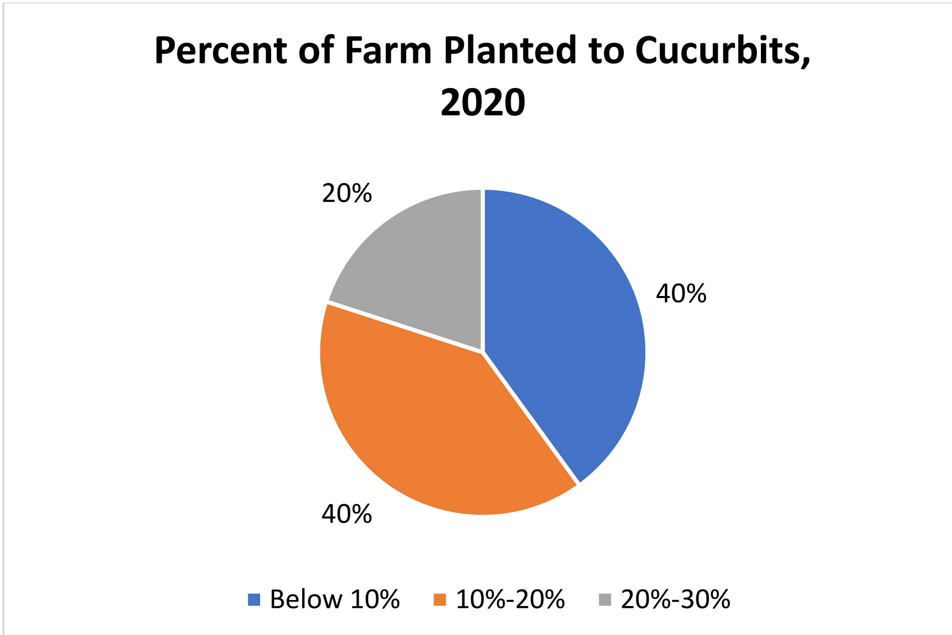


Figure 11. Percent of respondents' farms planted to cucurbit crops, 2019 (top) and 2020 (bottom).

As figure 12 shows, most grower respondents used university owned farmland and the rest leased or owned farmland. All respondents are experienced farmers, eight out of 13 have over 10 years' farming experience, and half of respondents have more than seven years' experience growing cucurbit, while only two were in their first year (see figure 13).

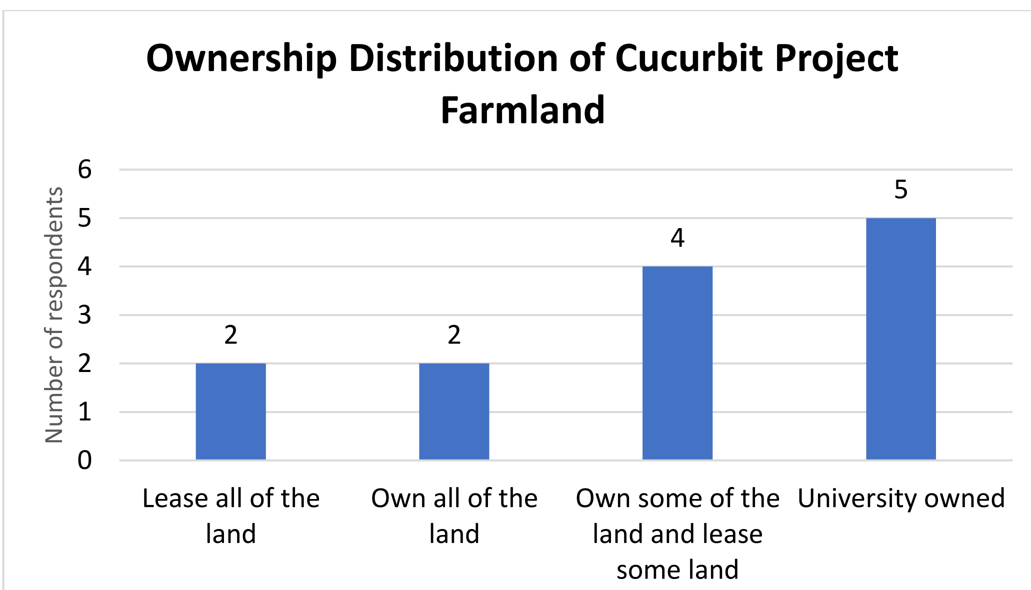


Figure 12. Ownership distribution of cucurbit project farmland.

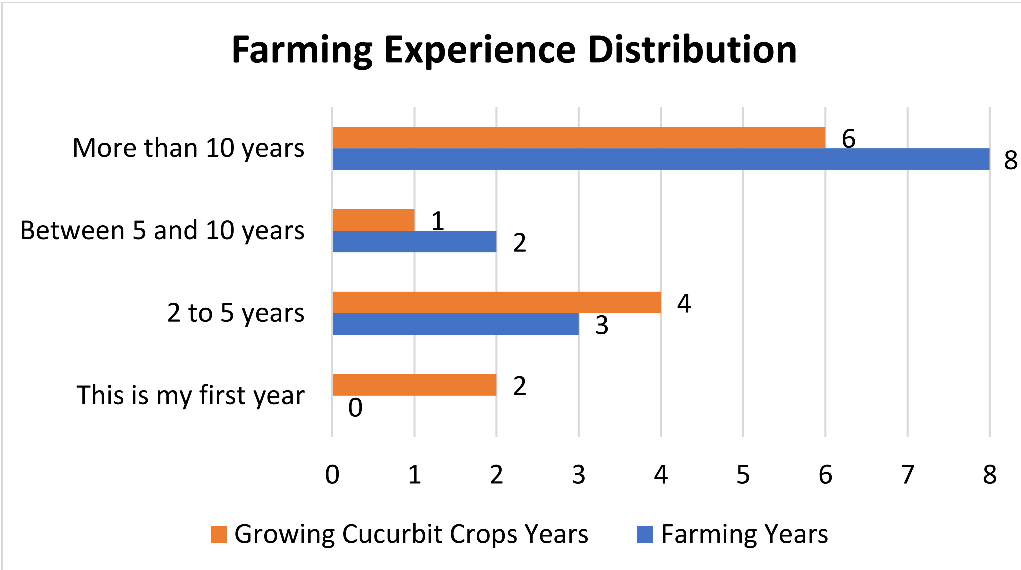


Figure 13. Distribution of respondents' farming experience.

5.2 Cucurbit Management

5.2.1 Crop and Permeable Row Cover Experiences

Respondents grew a diverse variety of cucurbit crops in 2020; however, melon and squash were the two primary crops grown. As figure 14 shows, all cucurbit crops except winter squash were planted on certified organic farms—winter squash was planted on a mix of certified (75%) and non-certified (25%) organic farms.

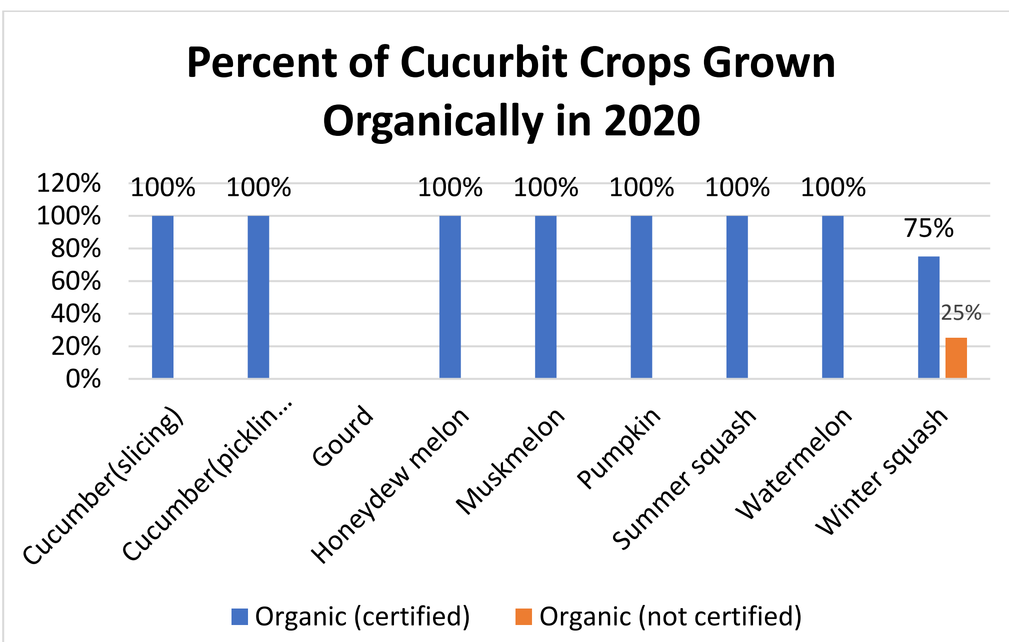


Figure 14. Percent of respondents' cucurbit crops grown organically in 2020.

Figure 15 shows that 77% respondents (10 out of 13) had experience with permeable row covers; and of those that do, 31% had previous experience with mesotunnels.

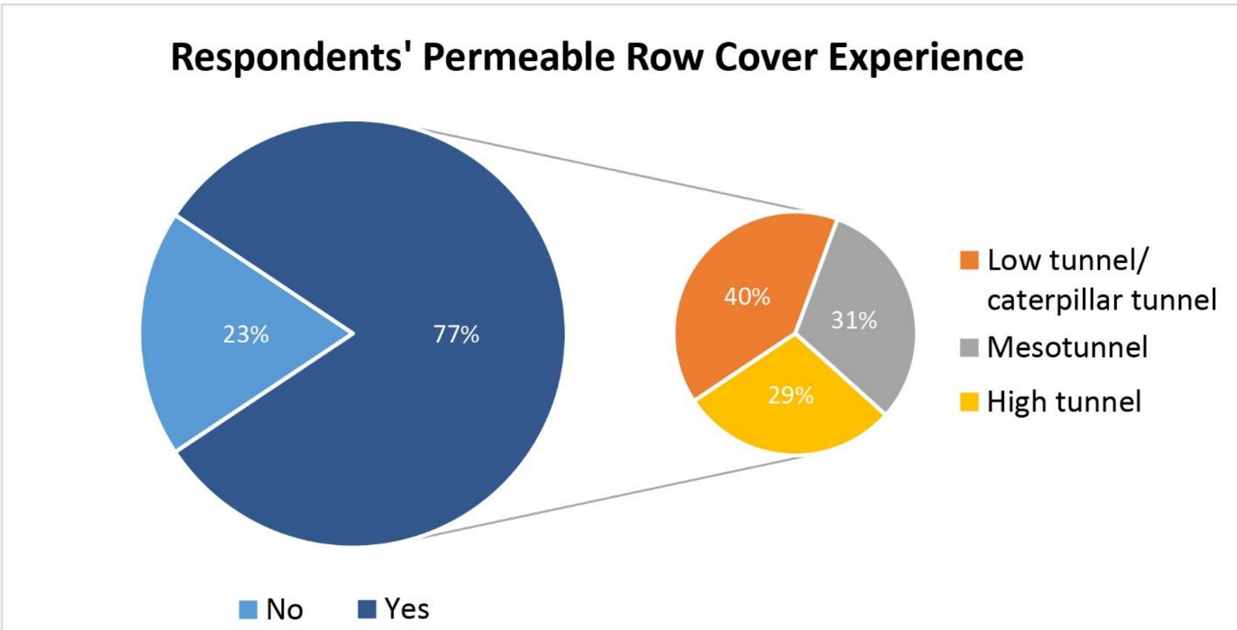


Figure 15. Whether respondents had experience with permeable row covers.

5.2.2 Pollination

Of the 13 respondents, seven used wild pollinators, five used a mixture of managed and wild pollinators, and one used managed bumble bees/honey bees/mason bees (see figure 16). As for pollinator effectiveness, eight out of 13 respondents were satisfied with their chosen method and thought that it worked well, four said their pollinator strategy worked but they would like to improve it, and one responded they "did not know" (see figure 17). For reference, figure 18 shows a bee pollinating a muskmelon flower.

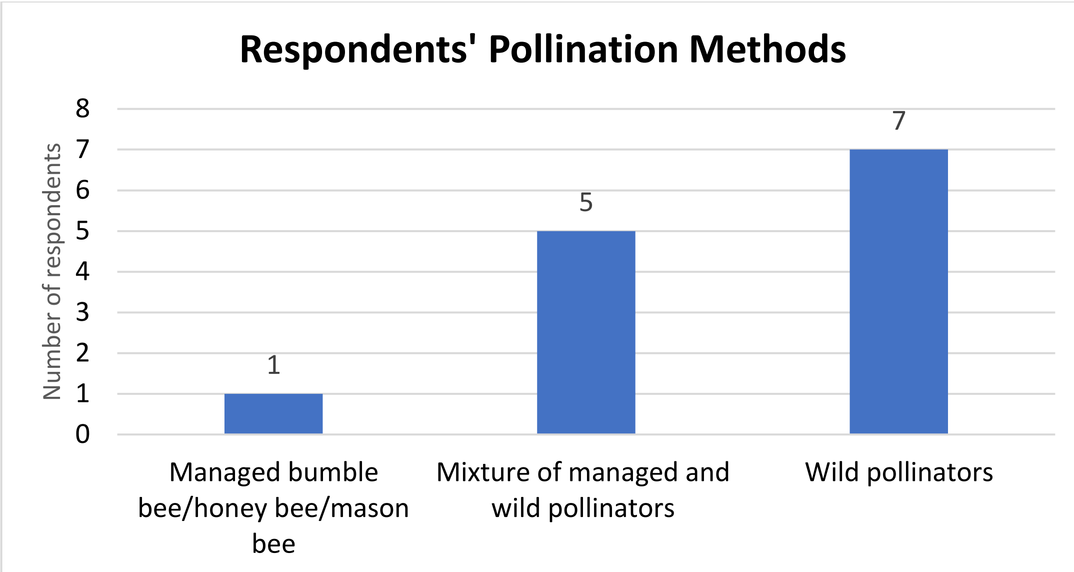


Figure 16. Distribution of respondents' pollination methods.

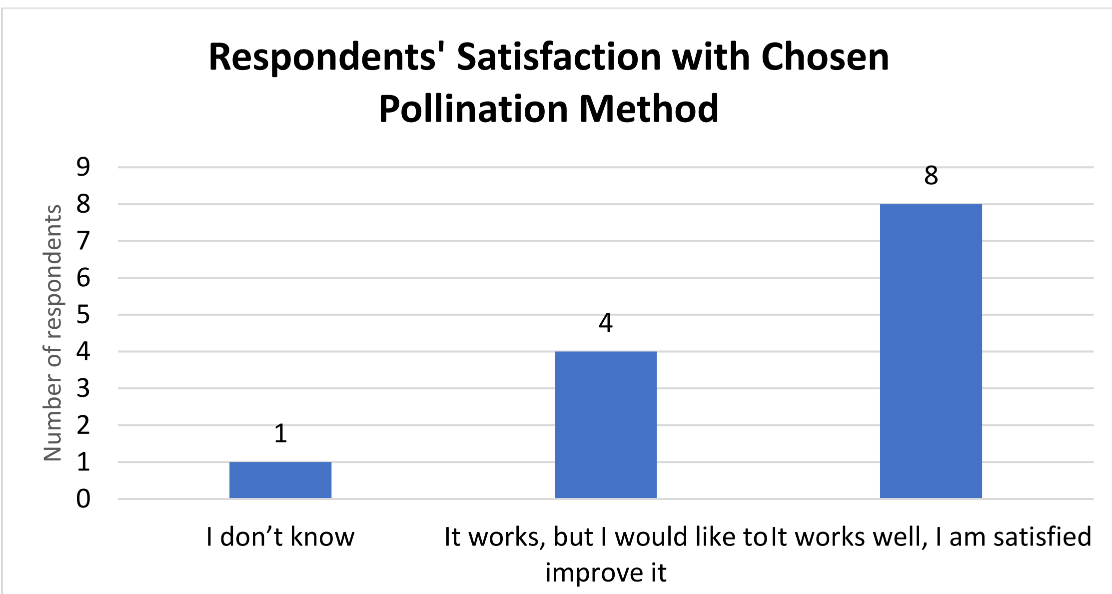


Figure 17. Respondents' satisfaction with chosen pollination method.

Figure 18. A bee pollinating a muskmelon flower. (Photo credit Jose Gonzalez, Iowa)

5.2.3 Weed Management

Respondents' methods for weed management were quite diverse (see figure 19). Most respondents chose cultivation and living mulch to manage weeds; however, four respondents chose other weed management methods including using a weed whacker, plastic mulch, and hand weeding. One respondent noted "during my CSA years, we just cultivated between beds until plants vined out. Then we rogue chop hoe if needed." For reference, figure 20 shows straw mulch used as weed management for a cucurbit crop.

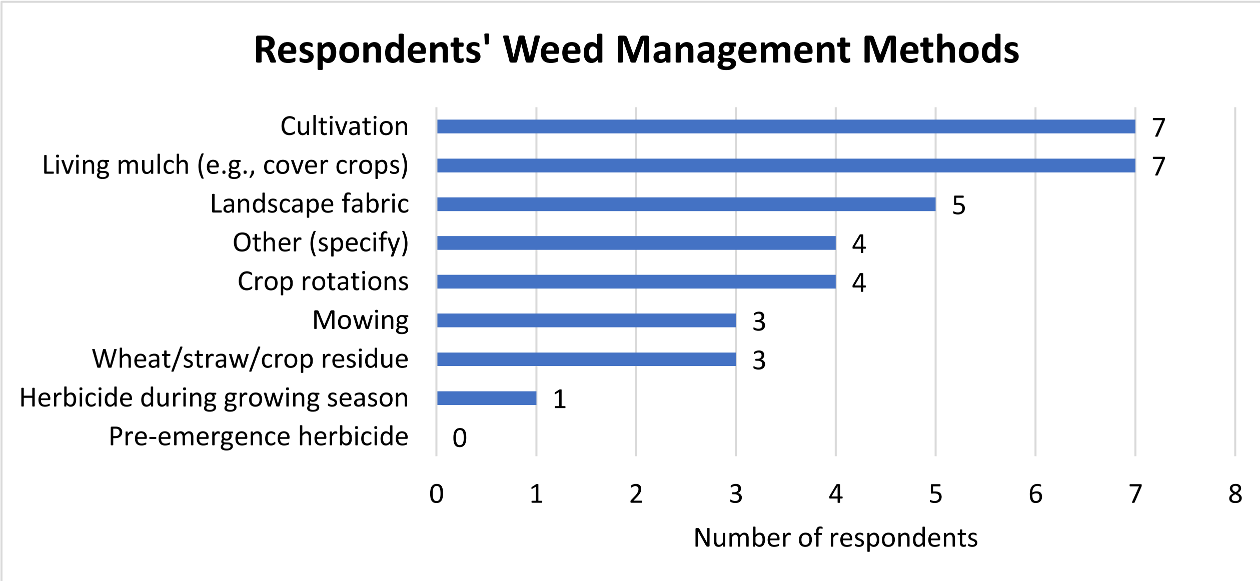


Figure 19. Distribution of respondents' weed management methods.

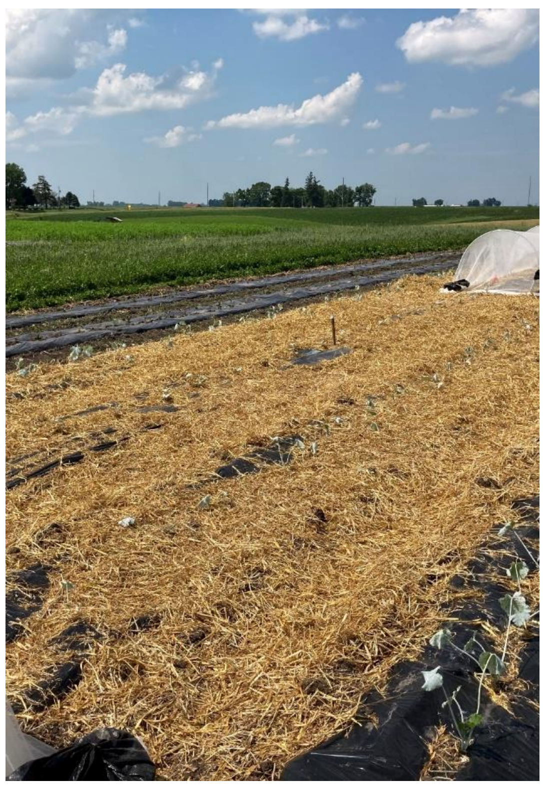


Figure 20. Weed management using straw mulch. (Photo credit by Ajay Nair, Iowa)

5.2.4 Cucurbit Crop Practices

Respondents used a wide variety of cucurbit crop practices, as figure 21 shows. The most popular practices were using a greenhouse or hoop house, planting cover crops, rotating crops, managing crop nutrition, using beneficial insects and natural enemies, and using drip/trickle irrigation. Most respondents reported never using precision agriculture with technology such as GPS, GNSS, variable-rate technology, no-till every year, or reduced tillage.

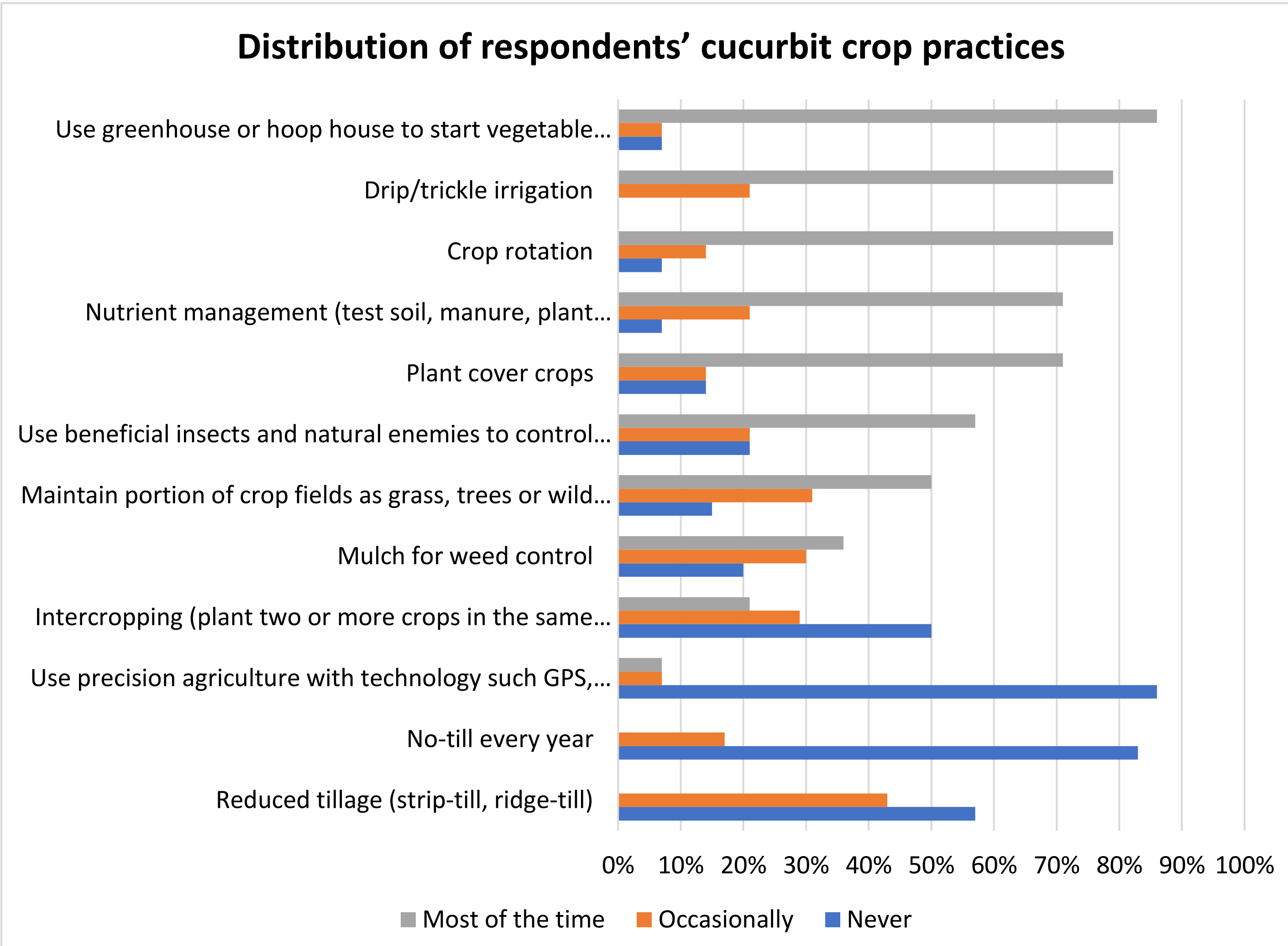


Figure 21. Distribution of respondents' cucurbit crop practices.

Of respondents who rotate crops, most used an end-of-season cover crop and planted a different vegetable crop subsequently. Figure 22 shows the crop varieties respondents reported rotating with cucurbit crops, which included oats, rye, peas, vetch, radish, winter wheat, red clover, beets, solanums, alliums, peppers, lettuce, and broccoli.

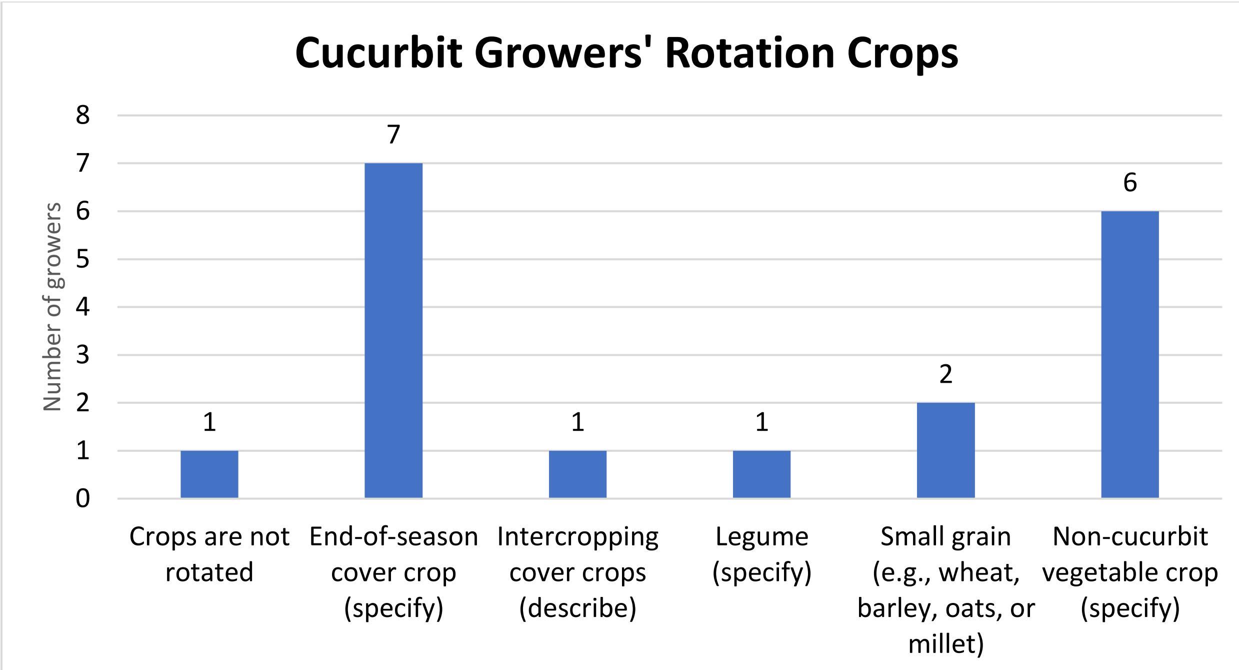


Figure 22. Distribution of crops used in rotation with cucurbit crops.

5.2.5 The Impact of Different Pest Management Systems on Profitability

When evaluating pest management system options, respondents felt that OMRI pesticide had a lot of impact on profitability and that the remaining options have only some impact on profitability, as figure 23 shows.

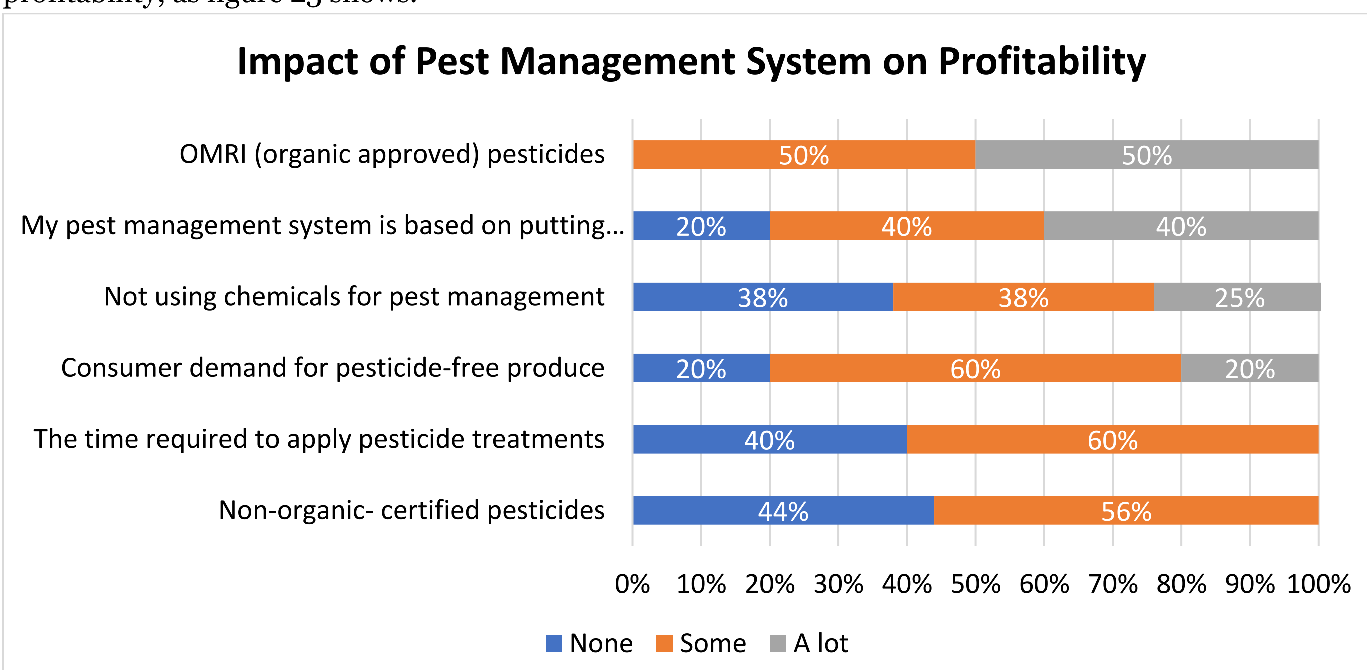


Figure 23. Respondents' impressions of pest management system impact on profitability.

5.2.6 Evaluation of the Effectiveness of Mesotunnel and Biocontrol Approaches

We presented respondents with six pre-written statements to evaluate their feelings on the effectiveness of different mesotunnel and bio-control approaches.

Statement 1: I am able to control major insect and disease pests all season to ensure a good muskmelon profit.

Of the eight respondents, three felt they are able to control major insect and disease problems all season to ensure a good muskmelon profit, two disagreed, and three were neutral (see figure 24).

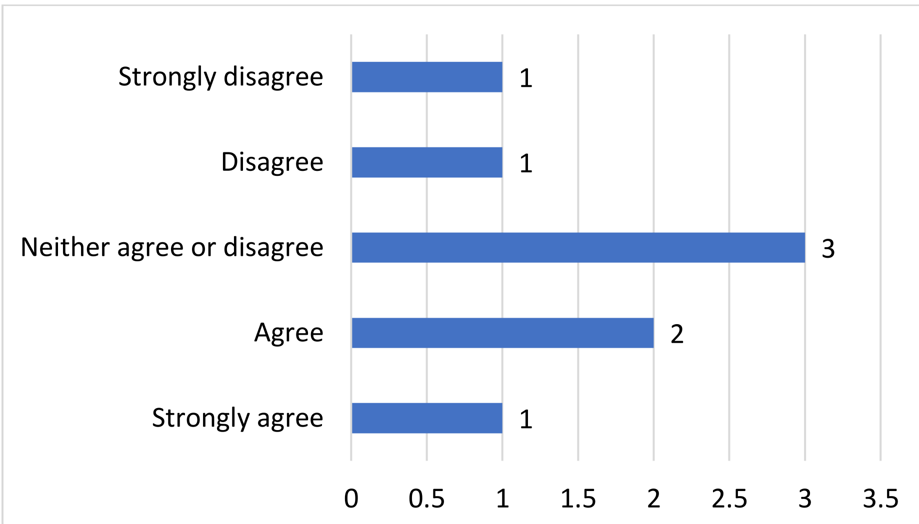


Figure 24. Distribution of respondents' answers to statement 1.

Statement 2: I am able to control major insect and disease pests all season to ensure a good winter squash profit.

Of the eight respondents, three felt they could ensure a good winter squash profit, one disagreed, and four were neutral (see figure 25).

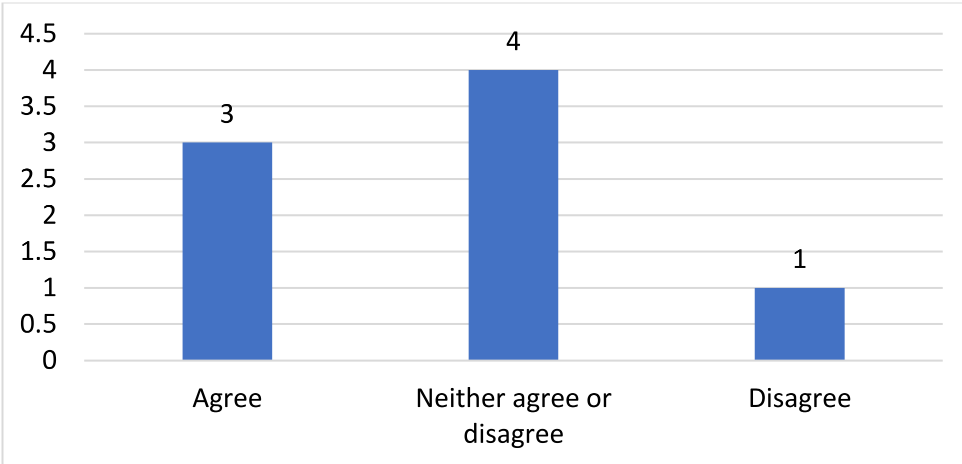


Figure 25. Distribution of respondents' answers to statement 2.

Statement 3: I am able to protect pollinators and/or natural-enemy insects by minimizing insecticide use in my organic cucurbit crops.

Statement 4: I am able to suppress weeds while enhancing soil health in my organic cucurbit crops.

When asked about the impact of mesotunnel and bio-control approaches on pollinators and soil health, 75% agreed that they could control the weeds while protecting soil health and 83% agreed that they could minimize insecticide use while protecting pollinators. Only a small percentage of respondents provided neutral answers (see figures 26 and 27).

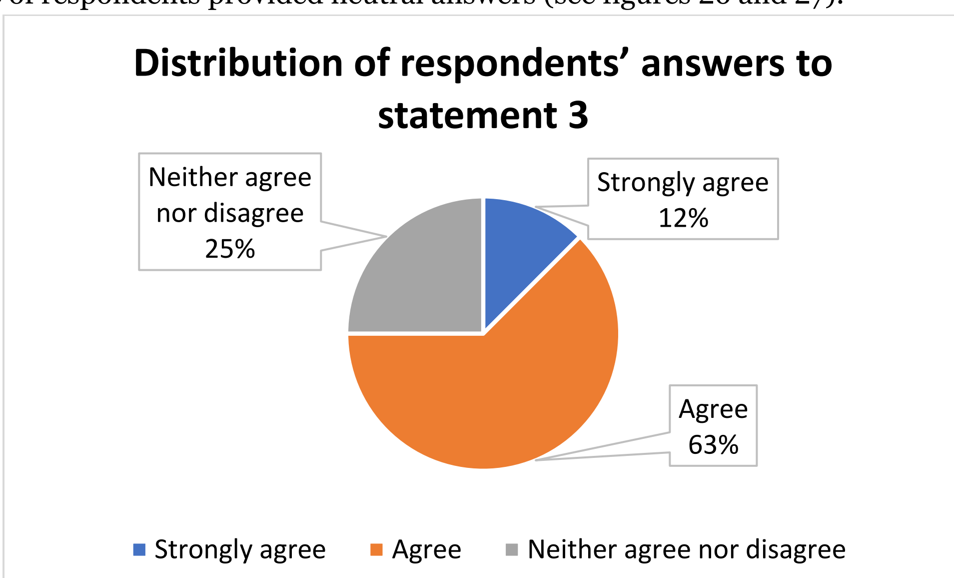


Figure 26. Distribution of respondents' answers to statement 3.

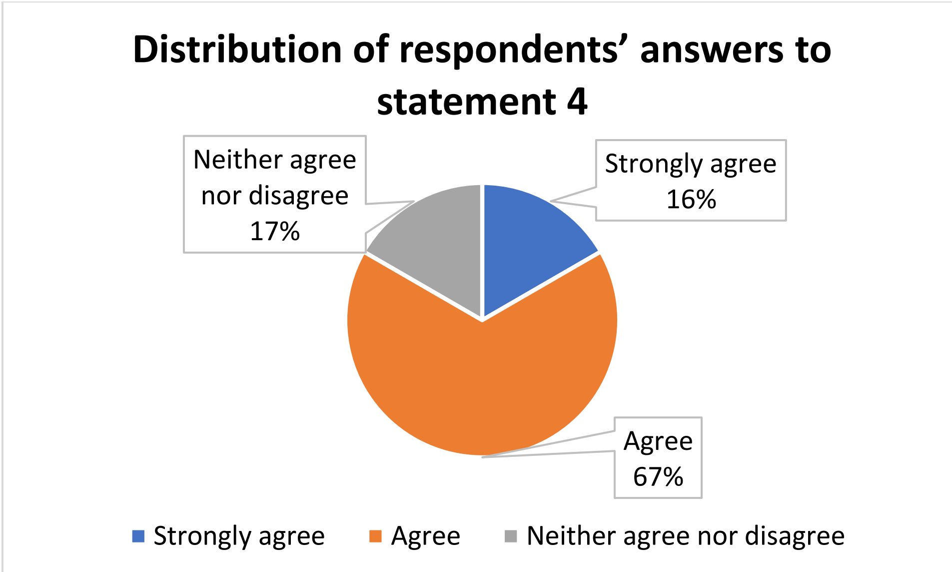


Figure 27. Distribution of respondents' answers to statement 4.

Statement 5: I would like to have more options for crop disease management through additional barrier-based (row cover) control options.

Statement 6: I would like to have more options for crop disease management through additional biological control options.

Of the 12 respondents to statement 5, 10 stated they would like to have more options to control crop disease through row cover control options (see figure 28). Of the seven respondents to statement 6, all respondents wanted more crop disease control options through additional biological controls (see figure 29).

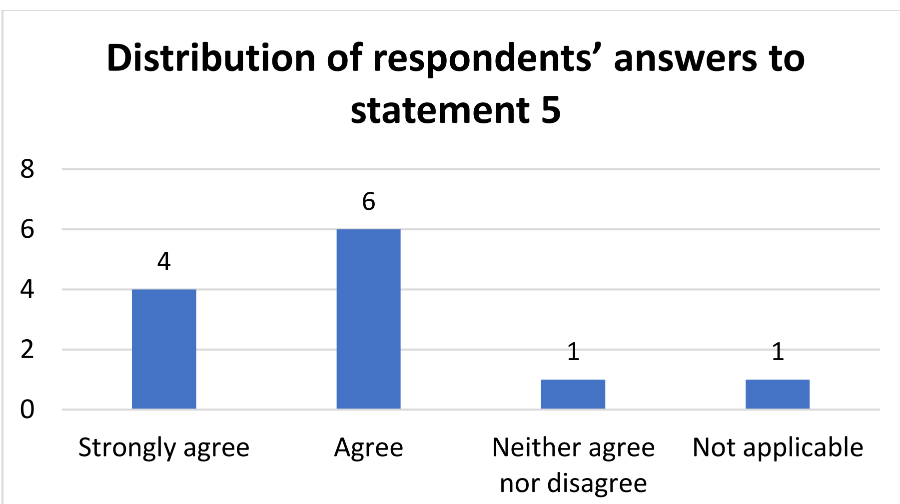


Figure 28. Distribution of respondents' answers to statement 5.

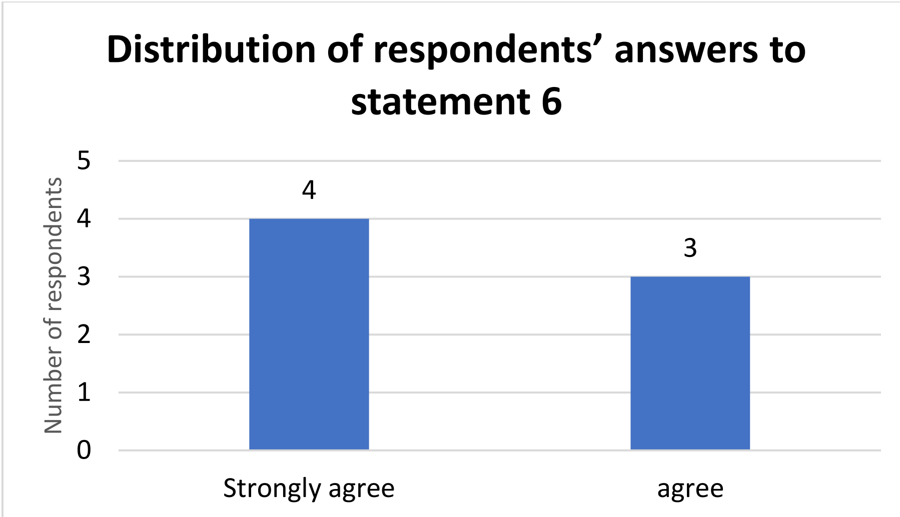


Figure 29. Distribution of respondents' answers to statement 6.

5.3 Biological Control Approaches to Cucurbit Pests and Diseases

5.3.1 Cucurbit Pests and Diseases

As figure 30 shows, respondents indicated that squash vine borers, cucumber beetles, squash bugs, and powdery mildew are the four most serious pests/diseases they encounter. However, respondents indicated they did not worry about these pests/diseases. As figure 31 shows, only a small fraction of respondents said they are very concerned about the four most serious pests/diseases when using reduced or non-pesticide to control pests/diseases.

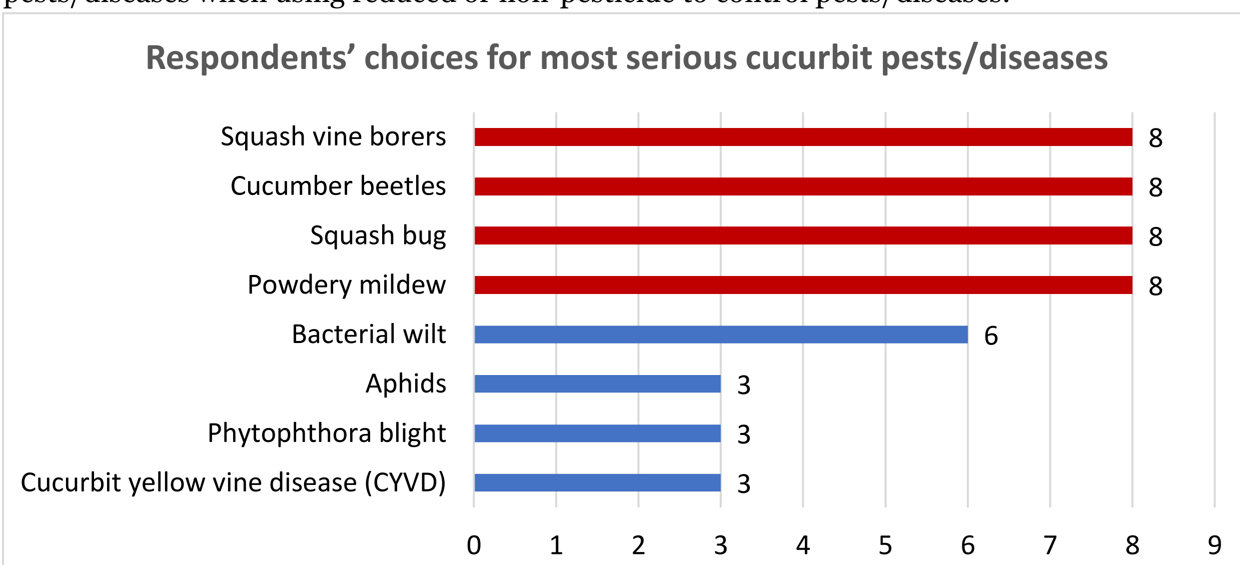


Figure 30. Respondents' choices for most serious cucurbit pests/diseases.

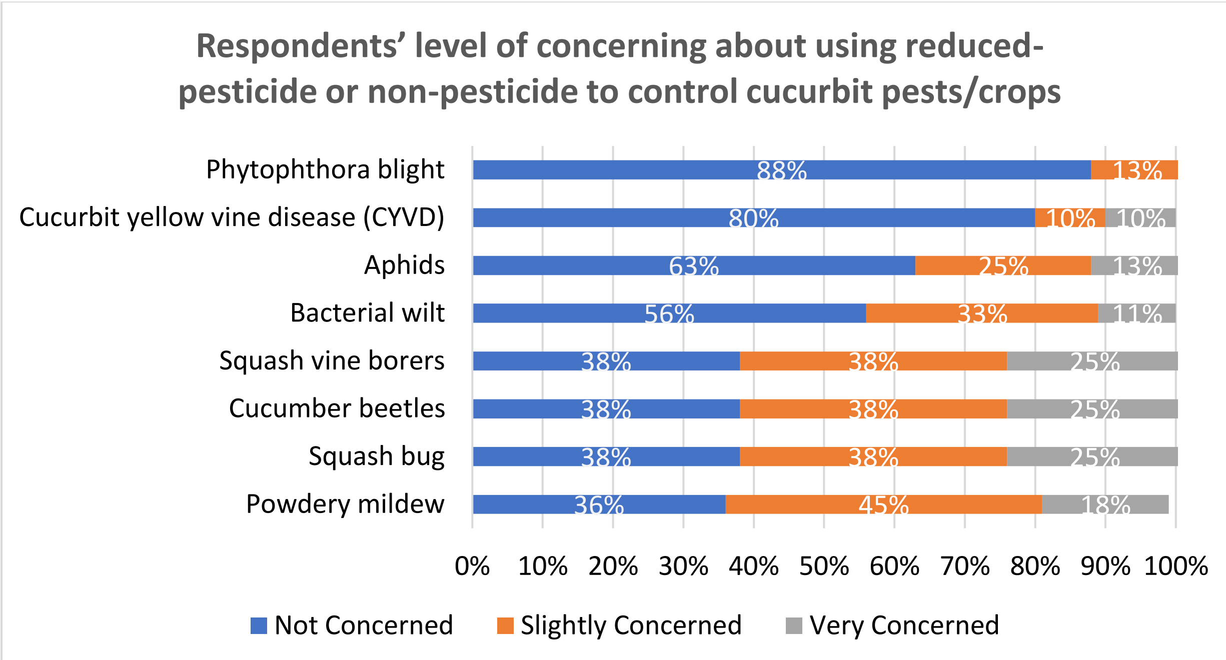


Figure 31. Respondents' level of concerning about using reduced-pesticide or non-pesticide measures to control cucurbit pests/crops.

5.3.2 Factors Impacting Pest Management System Decisions

When making the decision to use a particular type of pest management system, most respondents indicate improving yields, product quality, soil quality, and reducing pesticide runoff or leaching as the most important factors to consider (see figure 32).

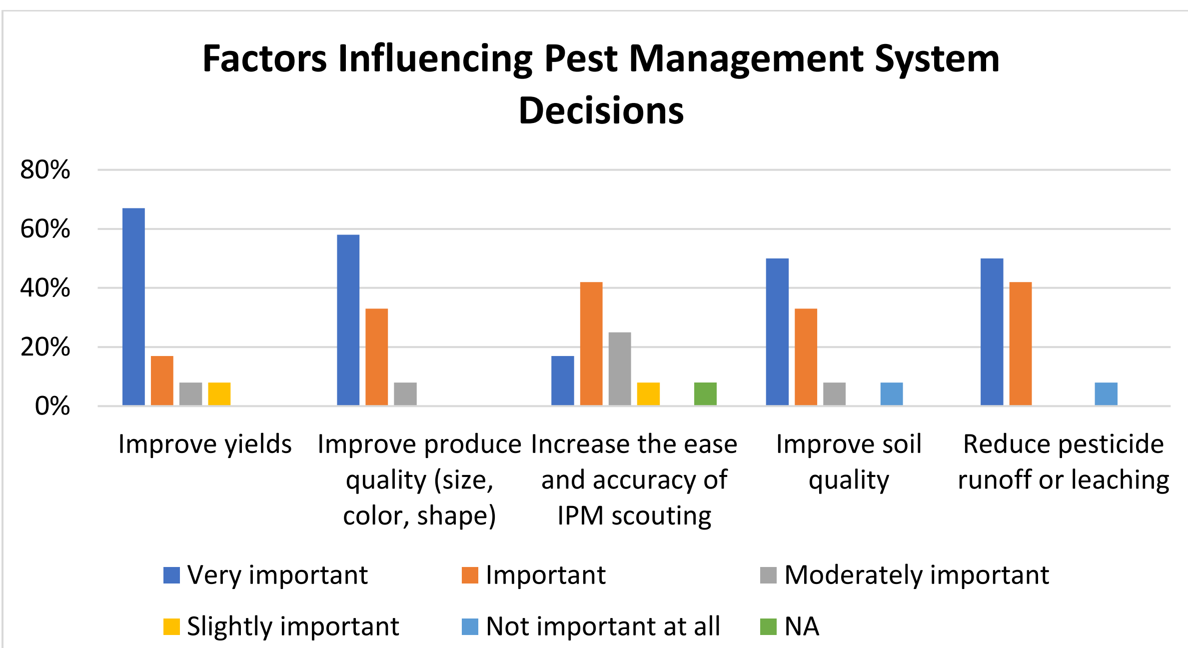


Figure 32. Respondents' feelings on factors in pest management system decisions.

Of the 12 respondents, eight report having biocontrol experience for managing pests/diseases (see figure 33). Advisory panel members and cooperators also reported having used biocontrols that include trap crop, ladybugs (on banker plants), high-tunnel predatory insects/mites, Double Nickel and Grandevo (on blueberries), mite control (on chestnuts), Double Nickel (on grapes), Pyganic, Surround, Monterey Garden Spray, Neem (on cucumbers, summer and winter squash), winter squash-lacewing larvae, and Dipel.

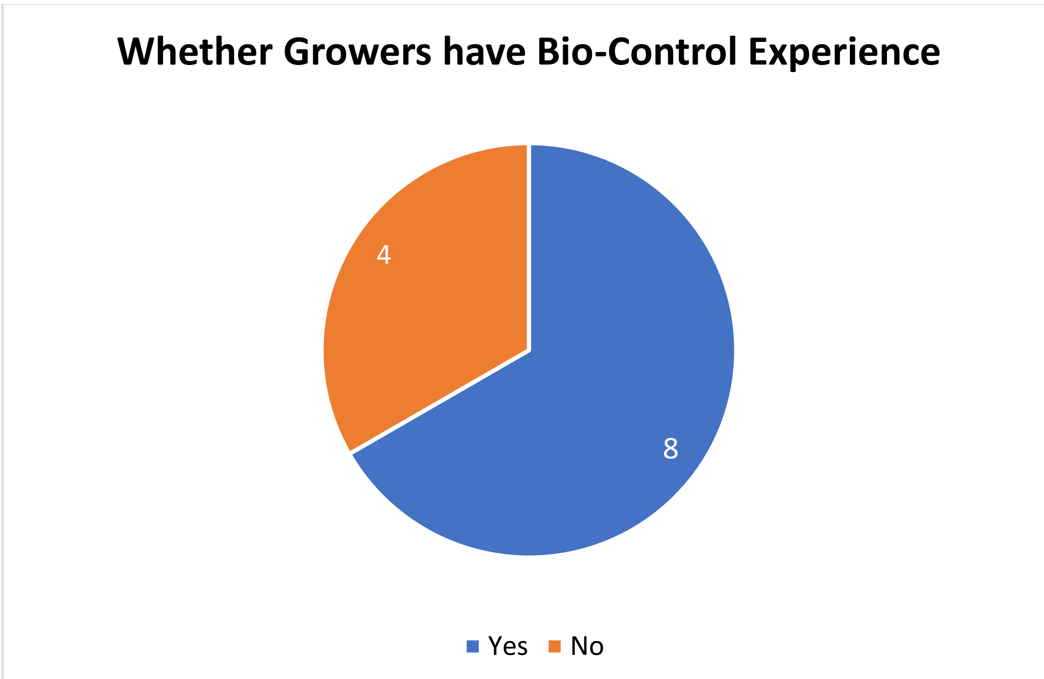


Figure 33. Whether growers have bio-control experience.

5.3.3 Challenges using Biocontrol Products for Pest/Disease Management

Of the 12 respondents, nine stated concerns about the effectiveness of biocontrol products. Respondents stated that two factors, ease of use of microbial-based biological products and effectiveness in improving product quality were only slightly concerning. Other concerns noted by respondents include selecting the appropriate biological control product, microbial-based biological product field timing, storage of microbial-based biological products, safety of biological products, capacity to translate IPM scouting into biological application, effectiveness in reducing diseases, effectiveness in increasing yield, impact on profitability, weather impacts on applications (timing, residual effectiveness, and formulation/strength), and personal perceptions/cautions and concerns about using biological controls.

5.3.4 Farm Operation Concerns

When asked about concerns about farm operation, respondents noted that increased pesticide loss to nearby water during heavy rain events is not a concern. As figure 34 shows, however, they were concerned with increased heat stress on crops, high winds, or increased insect and weed pressure. Respondents split almost equally on whether a higher incidence of crop disease, changes in activity or timing of pollinators, hail damage, increased soil erosion, availability of workers for the farm, and financial variability were concerns.

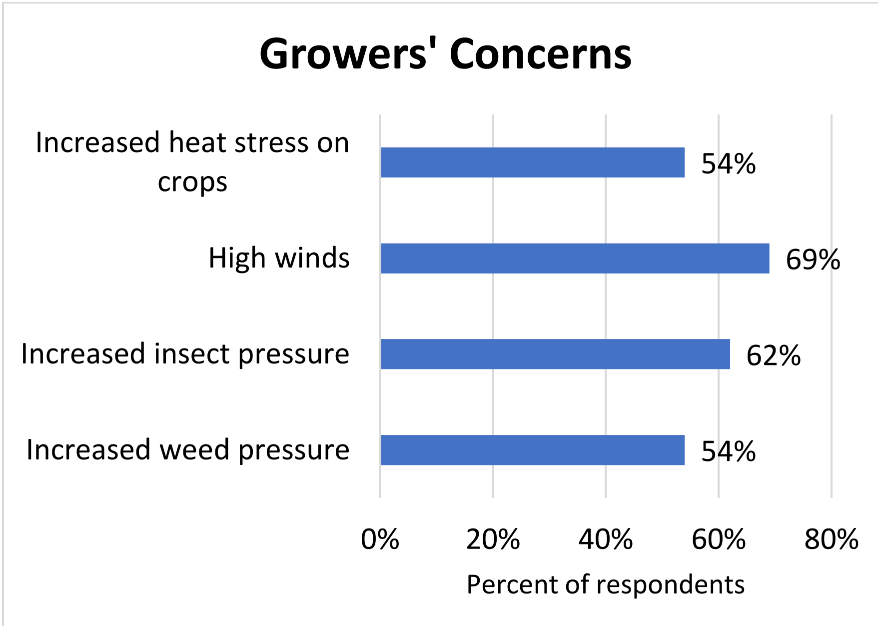


Figure 34. Which factors most concern cucurbit growers.

All respondents stated they regularly use spray equipment, with many stating they use multiple types. As figure 35 shows, most respondents prefer hand-pump backpacks, while the air blast is least preferred.

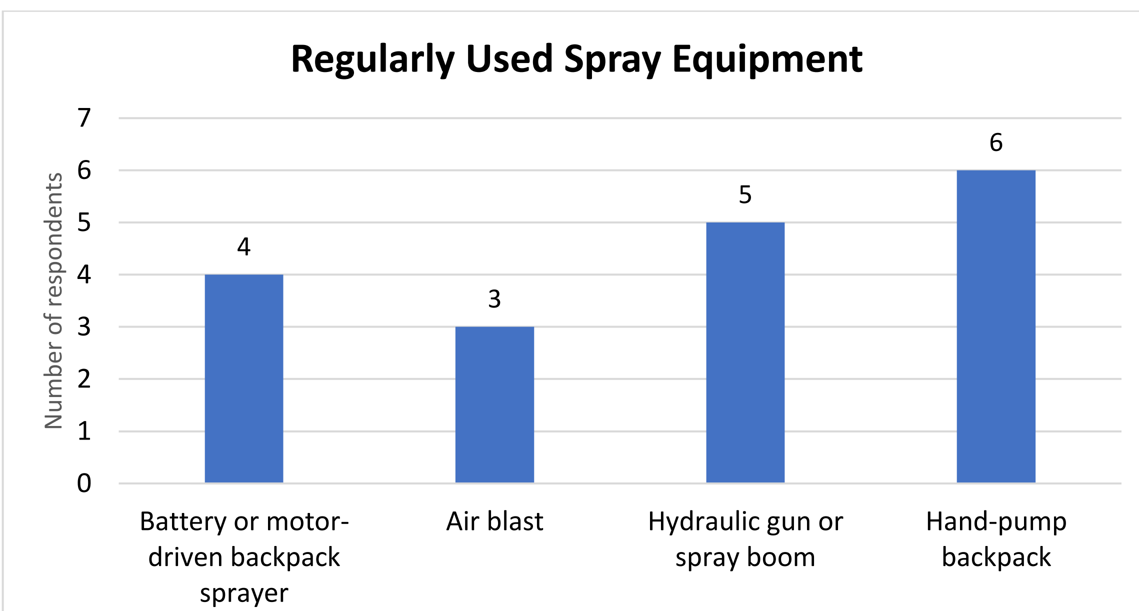


Figure 35. Types of spray equipment respondents use regularly.

6 Conclusions

The WTS focuses on how respondents choose to adopt mesotunnel management systems and biological control approaches. Respondents rated economic factors related to profit, cost, and yield as very important. As for non-economic factors, respondents' top concerns were plant growth and plant health. Furthermore, the survey shows most respondents were concerned with mesotunnel: (*a*) profitability; (*b*) cost-effectiveness; and, (*c*) scalability.

The CGS1 targeted growers and university field-trial managers and revealed that respondents had a lot of experience with cucurbit planting, the use of permeable row covers, different pollination and weed management methods, and pest management systems. Respondents were receptive to possible advantages of mesotunnel and bio-control approaches in cucurbit production; however, they hoped for more options for crop disease management.

According to the surveys above, respondents showed positive evaluation of mesotunnel and biological control approaches, even without the knowledge of profitability and cost-effectiveness of the mesotunnel and biological control approaches. This implies an understanding that if mesotunnel and biological control approaches can be profitable, cost-effective and capable to scale up, it is quite important for growers to adopt those technologies and spread these technologies to other growers as well.

To answer these questions, we will compare economic profitability and cost effectiveness of mesotunnel systems and biological control approaches. By applying a partial budget analysis to data from years 1–3 mesotunnel field trials and year 3 biological control field trials, we can: (*a*) compare profitability of the new systems to current organic production systems; and (*b*) assess how cost-effectiveness of the new systems vary across farm size, crop variety, soil characteristics, climatic conditions, and operator characteristics.

In year 3, we will use a mail and online survey of 500 cucurbit growers from Kentucky, New York, Iowa, and six other states to identify factors that promote or inhibit adoption of new systems and technologies for cucurbit production.